

# **FINAL DRAINAGE REPORT FOR SAN BERNARDINO COUNTY FIRE STATION NO.227**

**Project Location: 180 W. 38<sup>th</sup> Street, San Bernardino California.**

**APN-0154-281-01**

**Record: DRNSTY-2025-00006**

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Project Number: ERSC#09003097

Prepared for:

County of San Bernadino Project and  
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# ACRONYMS AND ABBREVIATIONS

BMP	best management practice
FEMA	Federal Emergency Management Agency
NOAA	National Oceanic and Atmospheric Administration
NS	None specified
SFHAs	Special Flood Hazard Areas
SWMP	Storm Water Management Plan

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# A. PROJECT DESCRIPTION

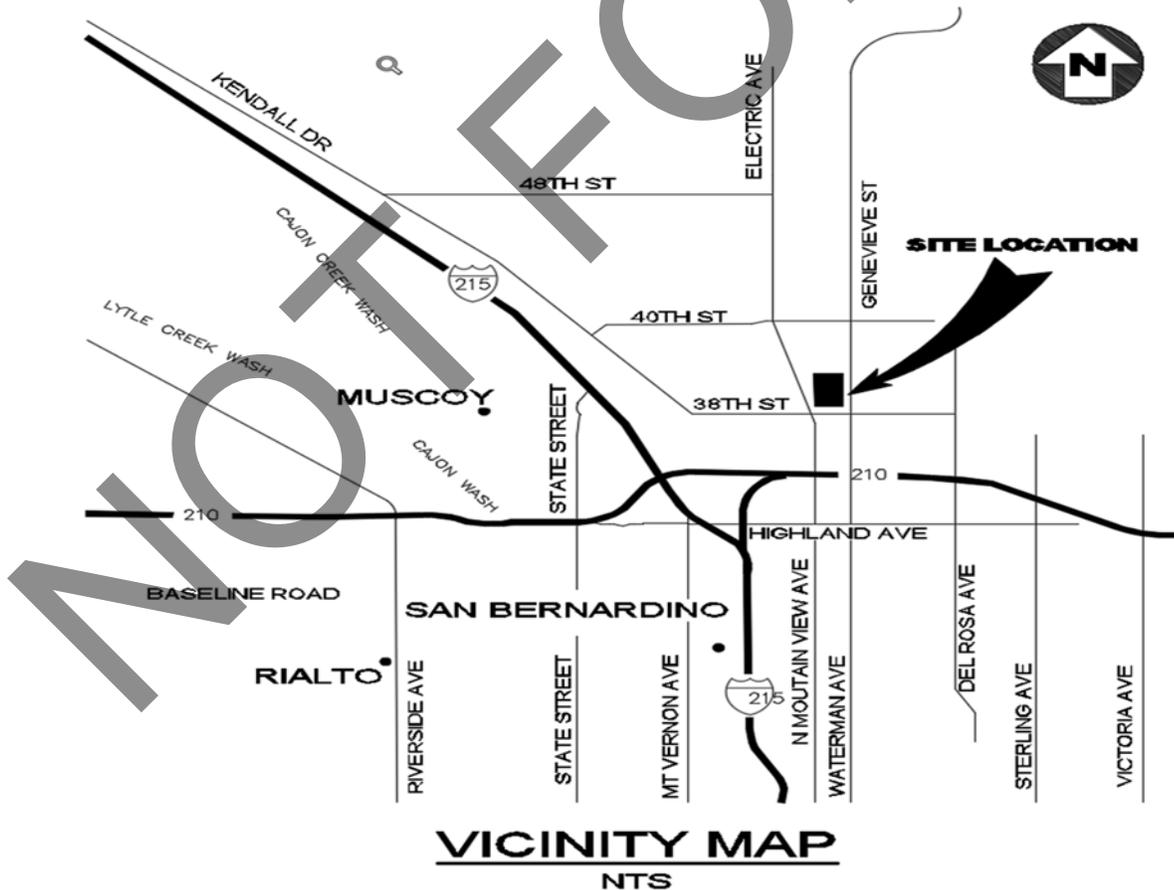
This drainage report has been prepared to address the stormwater management, hydrology, and drainage impacts of the proposed Fire Station No. 227. The project involves the construction of a 10,764 square-foot fire station on a 1.18-acre portion of the Arrowhead Elementary School play fields. The proposed facility includes a 3-bay apparatus garage, administrative offices, sleeping quarters, and site improvements such as parking areas, access roads, landscaping, and utilities.

This report evaluates the pre- and post-development hydrologic conditions and provides the necessary drainage improvements to mitigate 1-hour and 100-year storm event in accordance with local, state, and federal regulations.

## 1. LOCATION

The project area is located at the northwest corner of West 38th Street and Genevieve Street North in the San Bernardino, California. The proposed fire station No.227 will be located on the southern portion of the Arrowhead Elementary School property.

**Figure 1: PROJECT VICINITY MAP**



## 2. PROPOSED DEVELOPMENT

### 2.1 SITE DESCRIPTION

The existing site occupies 1.18 acres and is currently covered with a grass field and large trees on the east, west and south sides. The elevations at the site range from 1,294 to 1,284 feet above mean sea level (msl). The site slopes generally to the southeast with approximately 2 percent.

### 2.2 TOPOGRAPHY AND SOILS

The project site is located in San Bernardino County, California, within the southwestern region of the county. The ground elevation across the site is relatively flat, with a gentle slope toward the southeast.

The predominant soil type on the project site is Hanford coarse sandy loam (HaC), which is classified as Type A soil. This soil type covers 100% of the project site and is characterized by high infiltration rates and low runoff potential. Type A soils are well-drained and highly permeable, allowing water to easily percolate into the ground. These characteristics are ideal for infiltration-based stormwater management systems, which are effective in managing and treating runoff at the source.

The high infiltration capacity of Type A soils makes them suitable for implementing infiltration trenches, bioretention areas, and pervious pavement systems, which are designed to manage stormwater by allowing it to infiltrate into the subsurface. This will help minimize surface runoff, reduce the risk of flooding, and improve groundwater recharge.

Soil data for this site was obtained from the NRCS Web Soil Survey, which can be found in **Appendix 1** of this report. These soil characteristics will play a critical role in the design and placement of stormwater management facilities, ensuring that the system effectively handles both stormwater quantity and quality in compliance with local regulations.

**Figure 2: existing Project Area Map**



**Table 1: NRSC Web Soil Survey Soil Types**

Map Symbol	Description	Hydrologic Soil Group
<b>HaC</b>	Honford coarse Sandy loam, 2 to 9 percent slopes	A

## B. HISTORIC DRAINAGE

### 1. OVERALL DRAINAGE AREA DESCRIPTION

The project site, located in a heavily urbanized area, historically manages stormwater runoff from adjacent streets via a system of street gutters and underground storm drains. The proposed development will increase impermeable surfaces, which will, in turn, increase runoff velocity. A method to capture or slow down and divert this flow across newly paved areas is needed to prevent issues. Due to the limited construction area of the proposed fire station, an underground infiltration chambers system has been proposed.

#### 1.1 FEMA FLOOD INSURANCE STUDY

The Federal Emergency Management Agency's (FEMA) Flood Map Service Center was used to identify flood hazard areas near the project site. The project site location is dominated by native grass and large trees, and it is located in Zone X (06071C7945H, effective 08/28/2008), an area of minimal flood hazard as defined by FEMA. Map number 06071C7945H display the site lies outside of the 100-year flood plain and is designated as Zone X (**Appendix 2**), which is designed as an area within the 500-year flood plain; therefore, development of the site will not be impacted by a FEMA designated 100-year flood plain.

### 2. HISTORICAL DRAINAGE PATTERNS THROUGH PROPERTY

The current drainage patterns indicate that stormwater runoff from the site flows over the grassed cover in a southerly direction towards West 38th Street, where it is ultimately captured by the existing curb and gutter system. The runoff is then directed into the city's storm drain system. Currently, the amount of runoff is minimal due to the permeability of the natural ground cover. However, the proposed development will change these patterns by increasing the impervious surface area, which will require the implementation of stormwater management practices.

## C. DESIGN CRITERIA

The proposed drainage improvements will consist of constructing a concrete V-ditch to redirect offsite runoff away from the proposed improvements. Additionally, multiple drainage structures such as curb and gutter, drainage ditches, catch basins, and infiltration chambers will be built to effectively capture and manage the runoff generated by the proposed improvements.

### 1. LIST REFERENCES

- [San Bernardino County Hydrology Manual \(June 1989\)](#)
- [NOAA ATLAS 14](#)
- [FEMA](#)

- [The County of San Bernadino Technical Guidance Document for Water Quality Management Plans \(June 2013\)](#)

## 2. HYDROLOGIC CRITERIA

### a. Rainfall data

The precipitation data has been provided in **Table 2: NOAA Atlas 14, Precipitation Data** and a copy of the source is provided in **Appendix 3**.

**Table 2: NOAA Atlas 14, Precipitation Data**

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
<b>60-min</b>	0.498	0.660	0.890	1.09	1.39	1.63	1.90	2.19	2.62	2.99

### b. Calculation method

Hydrological analyses for the Project are performed using the Rational Method and Unit Hydrograph Method to estimate the peak runoff rates for the pre- and post-development conditions for 100-year storm event. Parameters for Rational Method include rainfall intensity in inches per hour, a runoff coefficient representing the ratio of runoff depth to rainfall depth (dimensionless), and drainage area (A) in acres. The values of the runoff coefficient (C) and the rainfall intensity (I) are based on a study of drainage area characteristics such as type and condition of the runoff surfaces and the time of concentration. The Unit Hydrograph Method assumes that watershed storm rainfall-runoff relationships are characterized by watershed area, slope, and that watershed discharge is related to the total volume of runoff. See Appendix 4 & 5 for Rational Method and Unit Hydrograph calculations and pipe and under sidewalk drain sizing.

A detailed description and in-depth discussion of the Rational Method and the Unit Hydrograph Method can be found in the San Bernadino County Hydrology Manual (June 1989).

### c. Design frequency

Design frequencies for stormwater infrastructure are based on the San Bernadino County, which require a 100-year return period for major storm events.

## 3. HYDRAULIC CRITERIA

This project has been designed to meet the standards which reference the following:

- » The County of San Bernadino Technical Guidance Document for Water Quality Management Plans
- » Santa Ana Regional Water Quality Control Board for construction activities and post-construction site management
- » Weir Equation for Catch Basin Sizing:  $Q=3.33*L*(H^{1.55})$

#### d. Infiltration Chambers System

Infiltration chamber system will be developed for the project in compliance with the San Bernadino County to accommodate the 100-year storm event. See Appendix 9 for proposed WQMP Infiltrations chamber volume calculations.

The infiltration system is designed to capture the incremental increase of stormwater between existing and proposed conditions under the 100-year 24-hour storm event. The incremental increase was determined to be 216.5 cubic feet and the provided storage of the basin is 4,917 cubic feet. The max WSEL of the basin is 1283.85', and the system will drain in approximately 44 hours after the 100-year 24-hour storm event. When the capacity of the infiltration system is exceeded, stormwater will flow through a 12-inch emergency overflow pipe and then a 4' wide under sidewalk drain and flow North to 38<sup>th</sup> Street. Calculations can be found in **Appendix 5**.

**Table 3: Hydrograph Results**

Storm Event	Existing Condition		Proposed Condition	
	Volume (Ac-ft)	Peak Flow (cfs)	Volume (Ac-ft)	Peak Flow (cfs)
100-Year, 24-Hour	0.3338	3.31	0.3835	3.65

**Table 4: Basin Routing Results**

Storm Event	Incremental Increase	Storage Provided	Mitigated Flow (cfs)	Drawdown Time (hrs)
100-Year, 24-Hour	0.0497	.113	3.011	44

# D. DRAINAGE PLAN

## 1. GENERAL CONCEPT

- a. Detention ponding/water quality BMP plan, identify ownership/maintenance responsibilities.

The project is subject to the requirements of various water quality permits issued by the Santa Ana Regional Water Quality Control Board for construction activities and post-construction site management. These requirements include preparation of a Stormwater Pollution Prevention Plan (SWPPP) for construction activities and a Project Specific Water Quality Management Plan for post construction site management.

## 2. SPECIFIC DETAILS

- a. Drainage area Descriptions

Existing hydrology calculations are included in **Appendix 4**.

**Table 5: Existing Drainage Areas**

Drainage area ID	Area (acres)	% IMP	Q100 (cfs)
<b>TOTAL</b>	3.46	40	13.65

Proposed hydrology calculations are included in **Appendix 5**.

**Table 6: Proposed Condition**

Drainage area ID	Area (acres)	% IMP	Q100 (cfs)
<b>A</b>	2.22	40	9.77
<b>B &amp; C</b>	1.18	77	7.51
	3.4		17.28

# E. CONCLUSION

The undeveloped current flow rate is approximately 13.65 cubic feet per second per existing hydrology map in **Appendix 6**. The current drainage area in question has produced a lower runoff compared to the combined flow of 9.5 cubic feet per second (cfs) from offsite sources and the runoff generated by onsite development (FS227). When the reduced offsite drainage area is combined with the developed onsite area, a total runoff of 17.28 cfs is generated. The reduced offsite area specifically

generates a flow of 9.77 cfs, which will be directed and channeled through a concrete V-ditch. This flow will move from east to west, ultimately reaching the lowest point on the southwest corner of the Arrowhead Elementary School property. This runoff will then be directed through a wall opening at the southwest corner of Arrowhead Elementary School. A catch basin, along with two 8-inch concrete pipe outlets, will be utilized to manage the 10-year storm events. The 10-year storm event runoff from Existing Site A will be diverted via catch basin, 8-inch pipes and under sidewalk drain. Existing site A generates 4.975 cubic feet per second, and calculations demonstrating that the catch basin, 8-inch pipes and under sidewalk drain have been adequately sized can be found in **Appendix 5**. For major storm events, the proposed wall opening will handle the runoff effectively. The wall opening is designed to handle the flow of a 100-year storm event, ultimately releasing the tributary runoff flows at Genevieve Street per exiting proposed hydrology map in **Appendix 7**.

For more information on the wall opening and concrete V-ditch and catch basin, please refer to the attached grading plan in **Appendix 8**.

Hydrograph and Basin routing calculations have been provided in this report showing that the proposed chamber system can capture the incremental difference between existing and proposed conditions, as well as mitigating the peak flow below existing peak flow, calculations have been provided in **Appendix 5**.

The runoff from onsite (FS227) will flow as sheet flow through a concrete gutter and be directed into the catch basin system. The catch basin system will then route its flows into infiltration chambers as detailed in the Water Quality Management Plan (WQMP) report, with infiltration chambers calculations provided in **Appendix 9**. Any excess runoff that overflows the chambers will flow through a 12" pipe and then the 4' wide under sidewalk drain to finally discharge to 38<sup>th</sup> Street. By utilizing a combination of infiltration, detention, and water quality Best Management Practices (BMPs), we will effectively manage both the quantity and quality of stormwater, thereby minimizing any adverse effects on the surrounding area.

## F. LIST OF REFERENCES

### Maps

FEMA, FIRM Panels 06065C0829G, and 06065C0837G

### Criteria

San Bernadino Storm Drainage Criteria

National Oceanic and Atmospheric Administration (NOAA), Atlas 14

Natural Resources Conservation Service (NRCS) Web Soil Survey

NOAA National Centers for Environmental Information, Climate Normal

San Bernadino County Flood Control and Water Conservation District

Santa Ana Regional Water Quality Control Board for construction activities and post-construction site management

APPENDIX 1. GEOTECHNIAL REPORT &  
NRCS SOILS REPORT

September 6, 2024  
Project No. S168-193

**STK ARCHITECTURE, INC.**  
42095 Zeno Drive, Suite A15  
Temecula, California 92590

Attention: Tony Finaldi

Subject: Geotechnical Investigation  
Proposed Fire Station 227  
NWC Genevieve Street N. and W. 38<sup>th</sup> Street  
San Bernardino, California

Dear Mr. Finaldi:

This report presents the results of the geotechnical investigation for the proposed Fire Station 227. The investigation was conducted in general conformance with our proposal dated March 6, 2024.

This report includes project design and construction recommendations along with the field and laboratory data. The primary geotechnical issues are the potential for strong ground shaking and the presence of variable soil conditions within the building areas that will require removal and recompaction.

We appreciate the opportunity to work with you on this project. Please call if you have any questions or need any other information.

Sincerely,  
**INLAND FOUNDATION ENGINEERING, INC.**

**Allen D. Evans, P.E., G.E.**  
Principal

  
**Christopher Hogan Rangel, PG**  
Project Geologist  
ADE:CHR:sd



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## **INTRODUCTION**

This report presents the results of the geotechnical investigation conducted for the proposed San Bernardino County Fire Station 227. Fire Station 227 will be located on the northwest corner of Genevieve Street N. and W. 38<sup>th</sup> Street in San Bernardino, California. Our project understanding was based on the discussions with STK Architecture and review of the following plan.

- FS 227 – Conceptual Site Plan, W. 38<sup>th</sup> Street, San Bernardino, CA, prepared by STK Architecture Inc, dated June 12, 2024

## **SCOPE OF SERVICE**

The purpose of this geotechnical investigation was to provide geotechnical parameters for design and construction of the proposed project. The scope of the geotechnical services included:

- *Evaluation of existing geologic conditions at the site and review of potential geologic and seismic hazards.*
- *Evaluation of the local and regional tectonic setting and historical seismic activity, including a site-specific ground motion analysis.*
- *Reconnaissance of the site and surrounding area to ascertain the presence of unstable or adverse geologic conditions.*
- *Subsurface sampling and laboratory testing.*
- *Analysis of the data collected and the preparation of this report with geotechnical engineering conclusions and recommendations for design and construction.*

Evaluation of hazardous waste was not within the scope of services provided.

## **PROJECT DESCRIPTION**

The Fire Station No. 227 project will consist of the construction of a new single-story structure comprising approximately 9,870 square feet. The station will be constructed on the southerly portion of the existing Arrowhead Elementary School property.

The fire station will include 3 truck bays, sleeping quarters for 8 crew members and will provide storage for 2 Type 1 Engines and a future ladder truck. A storage building and generator / fuel tank pad will be constructed in the northwest site area. Foundations for

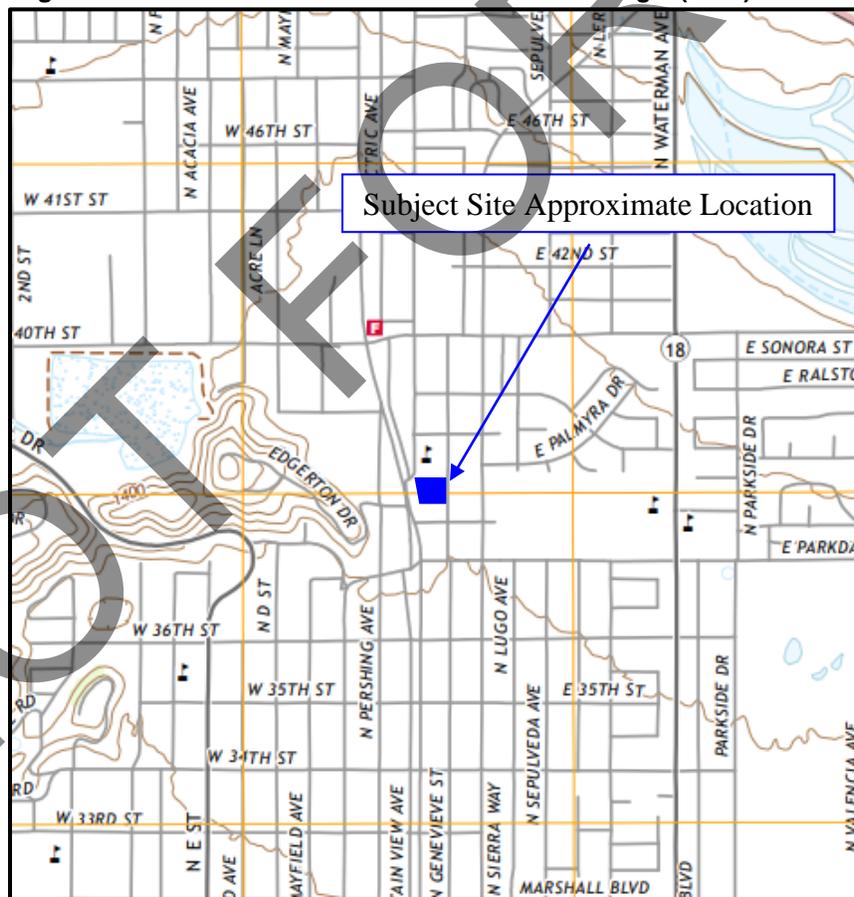
the proposed structures are expected to consist of shallow continuous and isolated concrete spread footings with slab-on-grade floors. Off-site improvements on Genevieve Street and 38<sup>th</sup> Street will be necessary. Site grading is expected to consist of minor cuts and fills of 2 to 3 feet, exclusive of remedial removals as recommended in this report.

Stormwater infiltration basins are planned in the southern and northwestern portions of the site. The basin depths are expected to be no deeper than five feet below existing surface grades.

### **SITE DESCRIPTION**

The subject site is located on the northwest corner of Genevieve Street N. and W. 38<sup>th</sup> Street in San Bernardino, California (34.160118°, -117.286677°). The site occupies 1.21 acres and is currently covered with a grass field and large trees on the east, west and south sides. Figure 1 below shows the site location.

**Figure 1: USGS San Bernardino North 7.5' Quadrangle (2021)**



According to Google Earth, elevations at the site range from 1,279 to 1,283 feet above mean sea level (msl). The site slopes generally to the south at an overall rate of approximately 2 percent.

**GEOLOGIC HAZARDS EVALUATION**

A geologic hazards report for this project was prepared by our subconsultant, Terra Geosciences, and is appended. The engineering geology and seismicity review was performed using the suggested “Checklist for the Review of Geologic/Seismic Reports for California Public Schools, Hospitals and Essential Services Buildings” (California Geologic Survey, Note 48, 2022).

The geologic hazards study indicates that the proposed fire station and associated structures are considered feasible from a geologic standpoint, providing that the conclusions and recommendations presented in the report are considered during planning and construction. No adverse geologic conditions were found within the proposed construction area, with the exception of the potential for strong ground shaking from nearby seismogenic fault sources.

The geologic hazards study included a site-specific ground motion analysis. The mapped spectral acceleration parameters, coefficients, and other related seismic parameters were evaluated using the OSHPD Seismic Design Maps web application (OSHPD, 2020) and the California Building Code criteria (CBC, 2022), with the site-specific ground motion analysis being performed following Section 21 of the ASCE 7-16 Standard (2017). The results of the site-specific analysis are summarized and tabulated in Table 1 below:

**Table 1: Seismic Design Parameters**

<b>Factor or Coefficient</b>	<b>Value</b>
$S_s$	2.506g
$S_1$	1.002g
$F_a$	1.2g
$F_v$	1.7g
$S_{DS}$	1.670g
$S_{D1}$	1.620g
$S_{MS}$	2.506g
$S_{M1}$	2.429g
$T_L$	8 Seconds
$MCE_G$ PGA	0.95g
Site Class	D

## **SUBSURFACE CONDITIONS**

Subsurface exploration at the site consisted of four (4) exploratory borings to depths ranging from approximately 16.5 to 50.5 feet below existing site grades. The site exploration is described in Appendix A. Boring locations are shown on Figure A-7.

The soil encountered in the borings consisted of quaternary alluvial materials comprised of interlayered silty sand (SM), sand with silt and gravel (SP/SW-SM), and silty clayey sand (SC-SM). Cobbles and boulders were encountered in boring B-01 at a depth of 30.5 feet. The soil encountered was generally fine to very coarse grained, loose to very dense and in a slightly moist to moist state.

**Corrosion Potential:** Analytical testing indicates the concentration of sulfates is 52 ppm. In accordance with ACI 318, Table 4.2.1, the soil is classified as having a negligible sulfate exposure. The chloride concentration in the tested sample was 30 ppm and indicates that the soil is generally not corrosive with respect to ferrous metal. The soil is alkaline with a pH value of 8.5. The saturated minimum resistivity value of 7,790 ohm-cm indicates the soil may be moderately corrosive to buried ferrous metal. Alternative material such as PVC piping should be considered in the project design. Inland Foundation Engineering, Inc. does not practice corrosion engineering. A qualified corrosion engineer should be consulted for additional guidance.

**Hydrocollapse Potential:** Consolidation testing indicates that the soil is compressible and normally consolidated. The results show a slight to moderate potential for hydrocollapse when saturated under anticipated foundation and soil overburden loads. Provided that the building pad area is prepared as recommended herein, and appropriate surface drainage is provided in accordance with contemporary design practice, the potential for adverse building settlement due to hydrocollapse is not significant.

**Expansive Soil:** The site soil is granular, non-plastic, and non-expansive. Design measures to mitigate soil expansion are not necessary.

**Groundwater:** Groundwater was not encountered within the exploratory borings, which extended to a maximum depth of 50.5 feet below existing ground surface. Based on a review of pertinent groundwater data (referenced in appended geologic hazards report), the depth to the high groundwater mark in the general region is greater than 120 feet.

**Liquefaction and Seismically-Induced Settlement:** In general, liquefaction is a phenomenon that occurs where there is a loss of strength or stiffness in the soil that can result in the settlement of buildings, ground failure, or other hazards. The main factors contributing to this phenomenon are: 1) cohesionless, granular soil with relatively low density (usually of Holocene age); 2) shallow ground water (generally less than 50 feet);

and 3) moderate to high seismic ground shaking. Based on current and historical groundwater levels of more than 120 feet below ground surface, the potential for soil liquefaction is not significant.

“Dry sand” settlement occurs in loose granular soil as a result of seismic ground shaking. The potential for “dry sand” settlement was evaluated using GeoSuite® software and Pradel’s method (1998). The results indicate a potential for seismically-induced “dry sand” settlement of less than 1 inch. The estimated differential seismic settlement is less than ½ inch over 30 feet. A discussion of the seismic settlement analysis, with graphic results, is included in Appendix D.

### **INFILTRATION TESTING**

Infiltration testing was conducted in general accordance with Appendix D of the Technical Guidance Document for Water Quality Management Plans, prepared by CDM Smith for the County of San Bernardino Areawide Stormwater Program (2013). The shallow percolation test method was used per the Riverside County Department of Environmental Health guidelines. Four percolation tests were performed at the locations shown on Figure A-7. The testing procedures are described, and the test data is included in Appendix C of this report.

The test results are shown in Table 2. The corresponding calculated infiltration rate ( $I_c$ ) ranges from 2.0 inches per hour to 5.7 inches per hour. These values exclude a factor of safety. The appropriate factor of safety should be determined by the design engineer.

**Table 2: Infiltration Rate**

<b>Percolation Test No.</b>	<b>Percolation Rate (min/in)</b>	<b>Depth Below Ground Surface (in)</b>	<b>Infiltration Rate (<math>I_c</math>) (in/hr)</b>
P-01	1.0	60	5.7
P-02	1.0	48	5.7
P-03	2.5	60	2.0
P-04	1.0	48	5.7

### **CONCLUSIONS AND RECOMMENDATIONS**

The primary geotechnical issue that will require mitigation is the presence of loose compressible near surface soil conditions within the proposed structure areas. The near surface soil is not suitable for supporting foundations in its existing condition and should be over-excavated and recompacted. This and other geotechnical engineering recommendations for project design and construction are presented below.

**Foundation Design:** The proposed fire station and associated structures can be supported by shallow continuous and isolated spread footings designed with an allowable bearing pressure of 2,000 pounds per square foot (psf). Footings should have a minimum width of 12 inches and bottoms a minimum depth of 12 inches below the lowest adjacent grade. The allowable bearing pressure can be increased by 400 psf for each additional foot of width and by 800 psf for each additional foot of depth, to a maximum allowable bearing pressure of 4,000 psf. The allowable bearing pressure can be further increased by  $\frac{1}{3}$  for short-term transient wind and seismic loads.

Static settlement of footings designed and constructed as recommended herein is expected to be less than one inch. Differential settlement between footings of similar size and load is expected to be less than one-half inch.

**Lateral Resistance:** Resistance to lateral loads will be provided by a combination of friction acting at the base of the slab or foundation and passive earth pressure. A coefficient of friction of 0.45 between soil and concrete may be used with dead load forces only. A passive earth pressure of 250 psf/ft may be used for the sides of footings poured against recompacted or dense native material. These values may be increased by  $\frac{1}{3}$  for short-term transient wind and seismic loads. Passive earth pressure should be ignored within the upper one foot, except where confined as beneath a floor slab, for example.

**Lateral Earth Pressure:** Retaining walls should be designed for an active earth pressure equivalent to that exerted by a fluid weighing not less than 40 pcf. Any applicable construction or seismic surcharges should be added to this pressure. Retaining wall backfill should have an expansion index of less than 20.

**Concrete Slabs-on-Grade:** Concrete slabs-on-grade should have a minimum thickness of four inches. During final grading and prior to the placement of concrete, all surfaces to receive concrete slabs-on-grade should be compacted to maintain a minimum compacted fill thickness of 12 inches.

Load bearing slabs should be designed using a modulus of subgrade reaction (k) not exceeding 200 pounds per square inch per inch. This value is based on an applied foundation load area of 1.0 square foot. The k value should be reduced for larger foundation areas according to the following formula:

$$k_R = k \left( \frac{B+1}{2B} \right)^2$$

where  $k_R$  = reduced modulus of subgrade reaction  
B = foundation width (feet)

Slabs should be designed and constructed in accordance with the provisions of the American Concrete Institute (ACI). Shrinkage of concrete should be anticipated and will result in cracks in all concrete slabs-on-grade. Shrinkage cracks may be directed to saw-cut "control joints" spaced on the basis of slab thickness and reinforcement.

Control joint spacing in unreinforced concrete at maximum intervals equal to the slab thickness times 24 is recommended.

Slabs to receive moisture-sensitive coverings should be provided with a moisture vapor retarder/barrier designed and constructed according to the American Concrete Institute 302.1 R, Concrete Floor and Slab Construction, which addresses moisture vapor retarder/barrier construction. At a minimum, the vapor retarder/barrier should comply with ASTM E1745 and have a nominal thickness of at least 10 mils. The vapor retarder/barrier should be properly sealed, per the manufacturer's recommendations, and protected from punctures and other damage.

**Portland Cement Concrete (PCC) Pavement:** All surfaces that will support fire apparatus should be paved with Portland cement concrete (PCC). PCC pavement should consist of 9 inches of PCC over 6 inches of Class 2 aggregate base. The concrete should have a minimum 28-day modulus of rupture of 600 psi. This corresponds to a compressive strength of approximately 4,500 psi.

For all other areas that will utilize PCC pavement the below table can be utilized for design sections. The following Portland cement concrete pavement sections are based on the American Concrete Institute (ACI) Guide for Design and Construction of Concrete Parking Lots and Site Paving (ACI 330-21). The concrete to be utilized for Category A and B areas as well as pedestrian areas should have a minimum 28-day modulus of rupture of 500 psi. This corresponds to a compressive strength of approximately 2,500 psi. The actual pavement subgrade soil should be evaluated during construction to verify that the recommended pavement sections are appropriate.

**Table 3: Portland Cement Concrete Pavement**

Service	Concrete Thickness (in.)	Aggregate Base (in.)
Car parking and access lanes (Category A)	4.25	4.0
Entrance and truck service lanes (Category B)	5.25	4.0
Pedestrian, non-vehicular hardscape	4.0	0.0

The Class 2 aggregate base should comply with current Caltrans requirements. The aggregate base should be compacted to at least 95 percent relative compaction based on ASTM D1557. The upper 12 inches of pavement subgrade soil, below the aggregate base, should also be compacted to a minimum relative compaction of 95 percent.

The concrete pavement should be constructed with doweled joints and be restrained laterally by concrete curb/gutter or building foundations. The edges of the concrete should be protected from traffic loads by curbs or paved shoulders. If unrestrained pavement edges or non-doweled joints are desired, this firm should be contacted so that revised recommendations can be developed.

Construction joints should be sawcut in the pavement at a maximum spacing of 30 times the thickness of the slab, up to a maximum of 15 feet. Pavement sawcutting should be performed within 12 hours of concrete placement, preferably sooner. Sawcut depths should be equal to approximately ¼ of the slab thickness for conventional saws or one inch when early-entry saws are utilized on slabs nine inches thick or less. Construction joints should not be placed near flow lines. The use of plastic strips for formation of jointing is not recommended. The use of expansion joints is not recommended, except where the pavement will adjoin structures.

**Asphalt Concrete Pavement:** Recommended asphalt concrete structural pavement sections are shown below in Table 4.

**Table 4: Asphalt Concrete Pavement**

Service	Asphalt Concrete Thickness (ft.)	Base Course Thickness (ft.)
Light traffic (autos, parking areas, T.I. = 5.0)	0.25	0.35
Heavy traffic (trucks, driveways, T.I. = 7.0)	0.30	0.45

Inland Foundation Engineering, Inc. does not practice traffic engineering. The T.I. values used to develop the recommended pavement sections are typical for projects of this type. The project civil engineer or traffic engineer should review the T.I. values used to verify that they are appropriate for this project.

**General Site Grading:** All grading should be performed per the applicable provisions of the 2022 California Building Code and the following recommendations.

- 1. Clearing and Grubbing:** All building and pavement areas and all surfaces to receive compacted fill should be cleared of vegetation, debris, and other unsuitable materials. All such material should be disposed of off-site.

All undocumented artificial fill and loose native soil within the grading limits should be completely removed. Such material is suitable for use as compacted fill as recommended herein.

- 2. Preparation of Surfaces to Receive Compacted Fill:** All surfaces to receive compacted fill should be reviewed by a geologist or engineer from this firm prior

to processing. If roots or other deleterious materials are encountered or if the exposed excavation bottom is loose or unstable, additional over-excavation may be required until satisfactory conditions are encountered. Upon approval, surfaces to receive fill should be scarified to a minimum depth of eight inches, brought to near optimum moisture content, and compacted to a minimum of 90 percent relative compaction.

3. **Placement of Compacted Fill:** Fill materials consisting of on-site soil or approved imported granular soil should be spread in shallow lifts and compacted at near optimum moisture content to a minimum of 90 percent relative compaction, based on ASTM D1557. Fill placed within 10 feet of finish grade should not contain any particles larger than 12 inches (boulders). Boulder-size particles should be disposed of off-site or in designated rock disposal fill areas.
4. **Import Soil:** All proposed import soil should be tested prior to placement on the site to verify that it is not corrosive or expansive. Recommended import soil criteria are shown in the following Table 5.

**Table 5: Recommended Import Soil Criteria**

<b>Sieve Size</b>	<b>Recommended Criteria</b>
Percent Passing 3-Inch Sieve	100
Percent Passing No. 4 Sieve	85 – 100
Percent Passing No. 200 Sieve	15 – 40
Plasticity Index	Less than 15
Expansion Index (ASTM D4829)	20 or less (very low)
Organic content	Less than 1 percent by weight
Sulfates	< 1,000 ppm
Min. Resistivity	> 10,000 ohm-cm

5. **Preparation of Building Areas:** All proposed building areas should be over-excavated to a depth of at least 8 feet below existing grade or 24 inches below the bottom of the deepest footing, whichever is greater. Building area excavation should extend laterally for at least 5 feet outside of exterior building foundation lines. Following excavation, the exposed soil should be evaluated by this firm to verify it is suitable to receive compacted fill. The removed soil should be placed and compacted as recommended above. Soil within 5 feet of finish grade and within 2 feet of footing and slab bottoms should not contain any particles larger than 3 inches (cobbles).

- 6. Preparation of Paving Areas:** During final grading and immediately prior to the placement of aggregate base, all surfaces to receive asphalt concrete or Portland cement concrete paving should be processed to remove all particles larger than 3 inches within 12 inches of subgrade. The upper 12 inches of pavement subgrade should be tested to assure compaction for a depth of at least 12 inches. Compaction within proposed pavement areas should be to a minimum of 95 percent relative compaction for both the subgrade and base course.
- 7. Utility Trench Backfill:** Utility trench backfill consisting of the on-site soil types should be placed by mechanical compaction to a minimum of 90 percent relative compaction. This is with the exception of the upper 12 inches under pavement areas where the minimum relative compaction should be 95 percent. Jetting of the native soil is not recommended.
- 8. Testing and Observation:** During grading, tests and observations should be performed by a representative of this firm to verify that the grading is performed per the project specifications. Density testing should be performed per the current ASTM D1556 or ASTM D6938 test methods. The minimum acceptable degree of compaction should be 90 percent of the maximum dry density, based on ASTM D1557, except where superseded by more stringent requirements, such as beneath pavement. Where testing indicates insufficient density, additional compactive effort should be applied until retesting indicates satisfactory compaction.

## **LIMITATIONS**

The findings and recommendations presented in this report are based on the soil conditions encountered at the boring locations. Should conditions be encountered during grading that appear to be different than those indicated by this report, this office should be notified.

This report was prepared for STK Architecture, Inc. for their use in the design of the proposed Fire Station No. 227. This report may only be used by STK Architecture, Inc for this purpose. The use of this report by parties or for other purposes is not authorized without written permission by Inland Foundation Engineering, Inc. Inland Foundation Engineering, Inc. will not be liable for any projects connected with the unauthorized use of this report.

The recommendations of this report are considered to be preliminary. The final design parameters may only be determined or confirmed at the completion of site grading on the basis of observations made during the site grading operation. To this extent, this report is not considered to be complete until the completion of both the design process and the site preparation.

The information in this report represents professional opinions that have been developed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical consultants practicing in this or similar localities. No warranty, express or implied, is made.

## **REFERENCES**

American Concrete Institute 318 (2019), Building Code Requirements for Structural Concrete.

American Society of Civil Engineers (ASCE), 2017, Minimum Design Loads and Associated Criteria for Buildings and other Structures, ASCE Standard 7-16, 889pp.

California Building Standards Commission, 2022, California Building Code (CBC), California Code of Regulations, Title 24, Part 2, Volume 2.

County of San Bernardino (2013), Areawide Stormwater Program, Technical Guidance Document for Water Quality Management Plans

Terra Geosciences, Geologic Hazards Report, San Bernardino County Fire Station 227, NWC of 38<sup>th</sup> Street and Genevieve Avenue, City of San Bernardino, California, Project No. 244073-1, dated July 20, 2024

United States Geologic Survey, San Bernardino North 7.5' Quadrangle (2021)

NOT FOR BID

## APPENDIX A

### SITE EXPLORATION

Four exploratory borings were drilled at the approximate locations shown on Figure A-7. The materials encountered during drilling were logged by a staff geologist. Boring logs are included with this report as Figures A-3 through A-6.

Representative undisturbed soil samples were obtained within the borings by driving a modified California split spoon sampler and thin-walled steel penetration sampler. Representative bulk soil samples were also obtained from the excavation cuttings. Samples were placed in moisture sealed containers and transported to our laboratory for further testing and evaluation. Laboratory tests results are discussed and included in Appendix B.

NOT FOR BIDDING

## UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

PRIMARY DIVISIONS		GROUP SYMBOLS		SECONDARY DIVISIONS		
COARSE GRAINED SOILS	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN #4 SIEVE	CLEAN GRAVELS (LESS THAN) 5% FINES	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	
			GP		POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	
		GRAVEL WITH FINES	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN #4 SIEVE	CLEAN SANDS (LESS THAN) 5% FINES	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
			SP		POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	
		SANDS WITH FINES	SM		SILTY SANDS, SAND-SILT MIXTURES	
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES	
		FINE GRAINED SOILS	SILTS AND CLAYS LIQUID LIMIT IS LESS THAN 50	ML		INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS
				CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL				ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY		
SILTS AND CLAYS LIQUID LIMIT IS GREATER THAN 50	MH			INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDS OR SILTS, ELASTIC SILTS		
	CH			INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	OH			ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS		
HIGHLY ORGANIC SOILS	PT		PEAT, MUCK AND OTHER HIGHLY ORGANIC SOILS			
TYPICAL FORMATIONAL MATERIALS	SANDSTONES	SS				
	SILTSTONES	SH				
	CLAYSTONES	CS				
	LIMESTONES	LS				
	SHALE	SL				

## CONSISTENCY CRITERIA BASES ON FIELD TESTS

RELATIVE DENSITY – COARSE – GRAIN SOIL			CONSISTENCY – FINE-GRAIN SOIL		TORVANE	POCKET ** PENETROMETER	* NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1 3/8 INCH I.D.) SPLIT BARREL SAMPLER (ASTM -1586 STANDARD PENETRATION TEST)  ** UNCONFINED COMPRESSIVE STRENGTH IN TONS/SQ.FT. READ FROM POCKET PENETROMETER
RELATIVE DENSITY	SPT* (# BLOWS/FT)	RELATIVE DENSITY (%)	CONSISTENCY	SPT* (# BLOWS/FT)	UNDRAINED SHEAR STRENGTH (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	
VERY LOOSE	<4	0-15	Very Soft	<2	<0.13	<0.25	
LOOSE	4-10	15-35	Soft	2-4	0.13-0.25	0.25-0.5	
MEDIUM DENSE	10-30	35-65	Medium Stiff	4-8	0.25-0.5	0.5-1.0	
DENSE	30-50	65-85	Stiff	8-15	0.5-1.0	1.0-2.0	
VERY DENSE	>50	85-100	Very Stiff	15-30	1.0-2.0	2.0-4.0	
			Hard	>30	>2.0	>4.0	

### MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	Absence of moisture, dusty, dry to the touch
MOIST	Damp but no visible water
WET	Visible free water, usually soil is below water table

### CEMENTATION

DESCRIPTION	FIELD TEST
Weakly	Crumbled or breaks with handling or slight finger pressure
Moderately	Crumbles or breaks with considerable finger pressure
Strongly	Will not crumble or break with finger pressure

## EXPLANATION OF LOGS

# LOG OF BORING B-01

DRILLING RIG	<u>Mobile B-61</u>	DATE DRILLED	<u>7/11/24</u>	HAMMER TYPE	<u>Auto-Trip</u>
DRILLING METHOD	<u>Rotary Auger</u>	HAMMER WEIGHT	<u>140-lb.</u>	HAMMER DROP	<u>30-inches</u>
LOGGED BY	<u>FWC</u>	BORING DIAMETER	<u>8-inches</u>		
GROUND ELEVATION	<u>+/-</u>				

## SUMMARY OF SUBSURFACE CONDITIONS

This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered and is representative of interpretations made during drilling. Contrasting data derived from laboratory analysis may not be reflected in these representations.

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	DESCRIPTION	BULK SAMPLE	DRIVE SAMPLE	SAMPLE TYPE	BLOW COUNTS /6"	MOISTURE (%)	DRY UNIT WT. (pcf)
			<b>GRASS,</b>			AU			
	SM		<b>SILTY SAND,</b> with trace gravel, fine to very coarse, very dark grayish-brown (10YR 3/2), moist, medium dense.		⊗	SS	9	11	112
5	SP-SM		<b>SAND with SILT and GRAVEL,</b> fine to very coarse, gray-brown (2.5Y 5/2), slightly moist, medium dense.		⊗	AU	9		
	SM		<b>SAND with SILT and GRAVEL,</b> fine to very coarse, grayish-brown (10YR 3/2), moist, medium dense.		⊗	SS	6	6	93
	SM		<b>SILTY SAND,</b> with trace gravel, fine to very coarse, very dark grayish-brown (10YR 3/2), moist, medium dense.		⊗	SS	11		
10	SW-SM		<b>SAND with SILT and GRAVEL,</b> fine to coarse, grayish-brown (10YR 5/2), slightly moist, medium dense.		⊗	AU	8	5	113
	SW-SM				⊗	SS	13		
	SW-SM				⊗	SS	23	2	130
15	SW-SM				⊗	SS	18		
	SC-SM		<b>SILTY, CLAYEY SAND,</b> very fine to fine, olive-brown (2.5Y 4/4), moist, medium dense.		⊗	SS	9	12	117
	SC-SM				⊗	SS	10		
20	SW-SM		<b>SAND with SILT and GRAVEL,</b> fine to very coarse, light olive-brown (2.5Y 5/4), slightly moist, medium dense.		⊗	SS	18	5	114
	SW-SM				⊗	SS	25		
25	SM		<b>SILTY SAND,</b> with trace gravel, very fine to fine, grayish-brown (2.5Y 5/2), moist, dense.		⊗	SPT	33	10	
	SM				⊗	SPT	28		
	SW-SM		<b>SAND with SILT and GRAVEL,</b> fine to very coarse, gray-brown (2.5Y 5/2), slightly moist, medium dense.		⊗	SPT	30		
30	SW-SM				⊗	SPT	50/3"	2	
			<b>COBBLES and BOULDERS,</b>						
			End of boring at 30.8 feet. No groundwater encountered. Backfilled with native soil.						

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CLIENT	<u>STK Architecture, Inc.</u>
PROJECT NAME	<u>Fire Station #227</u>
PROJECT LOCATION	<u>NWC Genevieve St. &amp; W. 38th St.</u>
	<u>San Bernardino, CA</u>
PROJECT NUMBER	<u>S168-193</u>

FIGURE NO.  
  
**A-3**

# LOG OF BORING B-02

DRILLING RIG	<u>Mobile B-61</u>	DATE DRILLED	<u>7/11/24</u>	HAMMER TYPE	<u>Auto-Trip</u>
DRILLING METHOD	<u>Rotary Auger</u>	HAMMER WEIGHT	<u>140-lb.</u>	HAMMER DROP	<u>30-inches</u>
LOGGED BY	<u>FWC</u>	BORING DIAMETER	<u>8-inches</u>		
GROUND ELEVATION	<u>+/-</u>				

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	SUMMARY OF SUBSURFACE CONDITIONS				BULK SAMPLE	DRIVE SAMPLE	SAMPLE TYPE	BLOW COUNTS /6"	MOISTURE (%)	DRY UNIT WT. (pcf)
			This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered and is representative of interpretations made during drilling. Contrasting data derived from laboratory analysis may not be reflected in these representations.									
5	SM		<b>GRASS,</b> <b>SILTY SAND</b> , with trace gravel, fine to medium, dark grayish-brown (10YR 5/2), moist, loose.				☒	SS	6	5	109	
10	SM		<b>SILTY SAND</b> , with trace gravel, fine to medium, light olive-brown (2.5Y 5/2), slightly moist, medium dense.				☒	SS	4	9	106	
15	SP-SM		<b>SAND with SILT</b> , fine to coarse, dark grayish-brown (10YR 4/2), moist, loose to medium dense.				☒	SS	8	3	109	
20	SW-SM		<b>SAND with SILT and GRAVEL</b> , fine to medium, grayish-brown (10YR 5/2), slightly moist, medium dense.				☒	SS	12	8	110	
25	SW-SM						☒	SS	8	6	107	
30	GW		<b>GRAVEL with SAND</b> , fine to coarse, olive-gray (5Y 4/2), moist, dense.				☒	SS	12	3	117	
35			<b>SAND with SILT and GRAVEL</b> , fine to medium, olive-gray (5Y 5/2), slightly moist, dense.				☒	SPT	17	5		
40							☒	SPT	24	3		
45							☒	SPT	19	5		
50							☒	SPT	13	3		
50.5							☒	SPT	35	2		
50.5							☒	SPT	50	3		
50.5							☒	SPT	50	2		
50.5							☒	SPT	50/5"	3		
50.5							☒	SPT	31	3		
50.5							☒	SPT	50/5"	7		
End of boring at 50.5 feet. No groundwater encountered. Backfilled with native soil.												

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CLIENT	<u>STK Architecture, Inc.</u>
PROJECT NAME	<u>Fire Station #227</u>
PROJECT LOCATION	<u>NWC Genevieve St. &amp; W. 38th St.</u> <u>San Bernardino, CA</u>
PROJECT NUMBER	<u>S168-193</u>

FIGURE NO.  
**A-4**

# LOG OF BORING B-03

DRILLING RIG	<u>Mobile B-61</u>	DATE DRILLED	<u>7/11/24</u>	HAMMER TYPE	<u>Auto-Trip</u>
DRILLING METHOD	<u>Rotary Auger</u>	HAMMER WEIGHT	<u>140-lb.</u>	HAMMER DROP	<u>30-inches</u>
LOGGED BY	<u>FWC</u>	BORING DIAMETER	<u>8-inches</u>		
GROUND ELEVATION	<u>+/-</u>				

## SUMMARY OF SUBSURFACE CONDITIONS

This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered and is representative of interpretations made during drilling. Contrasting data derived from laboratory analysis may not be reflected in these representations.

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	DESCRIPTION	BULK SAMPLE	DRIVE SAMPLE	SAMPLE TYPE	BLOW COUNTS /6"	MOISTURE (%)	DRY UNIT WT. (pcf)
			<b>GRASS,</b> <b>SILTY SAND,</b> fine to medium, dark grayish-brown (2.5Y 4/2), slightly moist, loose.			AU			
5	SM		- rootlets throughout -			SS	3 6	4	107
			<b>SAND with SILT and GRAVEL,</b> fine to coarse, light olive-brown (2.5Y 5/3), slightly moist, medium dense.			AU			
10	SP-SM					SS	3 8	7	111
			<b>SAND with SILT and GRAVEL,</b> fine to coarse, OLIVE-GRAY (5y 4/2), slightly moist, medium dense.			SS	8 11	3	108
			<b>SAND with SILT and GRAVEL,</b> fine to coarse, light olive-brown (2.5Y 5/3), slightly moist, medium dense.			SS	12 25	4	116
15	SM		<b>SILTY SAND,</b> fine to coarse, brown (10YR 4/2), moist, medium dense.						
	SW-SM		<b>SAND with SILT and GRAVEL,</b> fine to coarse, light olive-brown (2.5Y 5/3), slightly moist, medium dense.						
	SM		<b>SILTY SAND with GRAVEL,</b> fine to medium, light olive-brown (2.5Y 5/3), slightly moist, medium dense.			SS	10 14	5	113
20	SW-SM		<b>SAND with SILT and GRAVEL,</b> fine to coarse, OLIVE-GRAY (5y 4/2), slightly moist, medium dense.						
			<b>SAND with SILT and GRAVEL,</b> fine to coarse, OLIVE-GRAY (5y 4/2), slightly moist, medium dense.			SS	21 35	2	131
			End of boring at 21.5 feet. No groundwater encountered. Backfilled with native soil.						

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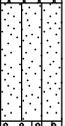
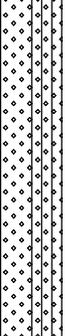
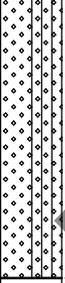


CLIENT	<u>STK Architecture, Inc.</u>
PROJECT NAME	<u>Fire Station #227</u>
PROJECT LOCATION	<u>NWC Genevieve St. &amp; W. 38th St.</u> <u>San Bernardino, CA</u>
PROJECT NUMBER	<u>S168-193</u>

FIGURE NO.  
  
**A-5**

# LOG OF BORING B-04

DRILLING RIG	<u>Mobile B-61</u>	DATE DRILLED	<u>7/11/24</u>	HAMMER TYPE	<u>Auto-Trip</u>
DRILLING METHOD	<u>Rotary Auger</u>	HAMMER WEIGHT	<u>140-lb.</u>	HAMMER DROP	<u>30-inches</u>
LOGGED BY	<u>FWC</u>	BORING DIAMETER	<u>8-inches</u>		
GROUND ELEVATION	<u>+/-</u>				

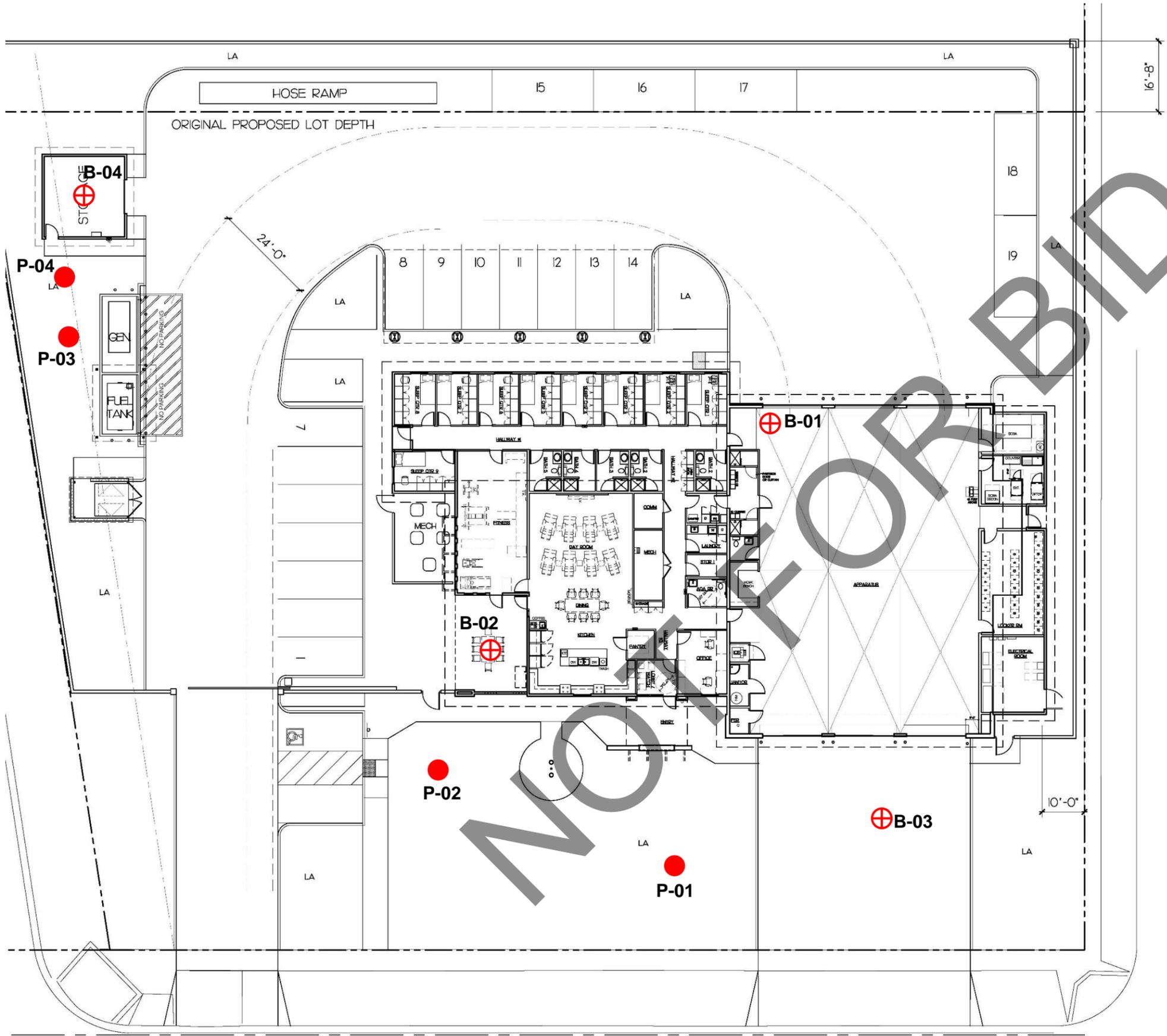
DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	SUMMARY OF SUBSURFACE CONDITIONS	BULK SAMPLE	DRIVE SAMPLE	SAMPLE TYPE	BLOW COUNTS /6"	MOISTURE (%)	DRY UNIT WT. (pcf)
			<p>This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered and is representative of interpretations made during drilling. Contrasting data derived from laboratory analysis may not be reflected in these representations.</p>						
	SM		<b>GRASS, ARTIFICIAL FILL, SILTY SAND</b> , with trace gravel, fine to medium, grayish-brown (10YR 5/2), slightly moist, medium dense.			AU			
	SM		<b>SILTY SAND</b> , fine to coarse, grayish-brown (10YR 5/2), slightly moist, medium dense.			SS AU	16 18	3	110
5	SW-SM		<b>SAND with SILT and GRAVEL</b> , with trace gravel, fine to coarse, light olive-brown 2.5Y 5/4), slightly moist, medium dense.			SS	10 14	3	115
	SW-SM					SS	8 8	6	102
10	GW		<b>GRAVEL with SAND</b> , fine to coarse, light olive-brown (2.5Y 5/4), slightly moist, medium dense.			SS	11 14	3	115
	SW-SM		<b>SAND with SILT and GRAVEL</b> , with trace gravel, fine to coarse, light olive-brown 2.5Y 5/4), slightly moist, medium dense.			SS			
15	SW-SM					SS	22 31	4	
			End of boring at 16.5 feet. No groundwater encountered. Backfilled with native soil.						

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CLIENT	<u>STK Architecture, Inc.</u>
PROJECT NAME	<u>Fire Station #227</u>
PROJECT LOCATION	<u>NWC Genevieve St. &amp; W. 38th St.</u> <u>San Bernardino, CA</u>
PROJECT NUMBER	<u>S168-193</u>

FIGURE NO.  
  
**A-6**



**SITE PLAN**  
 STK Architecture, Inc.  
 Proposed Fire Station 227  
 NWC Genevieve Street N. and W. 38<sup>th</sup> Street  
 San Bernardino County, California

**LEGEND**

- Approximate Location of Exploratory Boring - ⊕
- Approximate Location of Percolation Test - ●

Base Map: Prepared by STK Architecture, Inc.



**IFE** Inland Foundation Engineering, Inc.  
 1310 S. Santa Fe Avenue, San Jacinto, CA 92583 | (951) 654-1555

Figure A-7	STK Architecture, Inc. Proposed Fire Station 227 San Bernardino County, California	
	Drawn By: HR	Project No. S168-193
	Not to Scale	Date: August 2024

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## APPENDIX B

### LABORATORY TESTING

Representative soil samples obtained from our borings were delivered to our laboratory. Descriptions of the tests performed are provided below. Results of the testing are appended.

**Unit Weight and Moisture Content:** Ring samples were weighed and measured to evaluate their unit weight. A small portion of each sample was then tested for moisture content. The testing was performed per ASTM D2937 and D2216. The results of this testing are shown on the boring logs (Figures A-3 through A-6).

**Maximum Density-Optimum Moisture:** One sample was selected for maximum density testing in accordance with ASTM D1557. The maximum density is compared to the in-situ density of the soil to evaluate the relative compaction of the soil. The results of the testing are shown on Figure B-3.

**Sieve Analysis:** Ten soil samples were selected for sieve analysis testing in accordance with ASTM D6913. These tests provide information for classifying the soil in accordance with the Unified Classification System. This classification system categorizes the soil into groups having similar engineering characteristics. The results of the testing are shown on Figures B-4 and B-5.

**Plastic Index:** Two samples were selected for plastic index testing in accordance with ASTM D4318. These tests provide information regarding soil plasticity and are also used for developing classifications for the soil in accordance with the Unified Classification System. The results of the testing are shown on Figures B-4 and B-5.

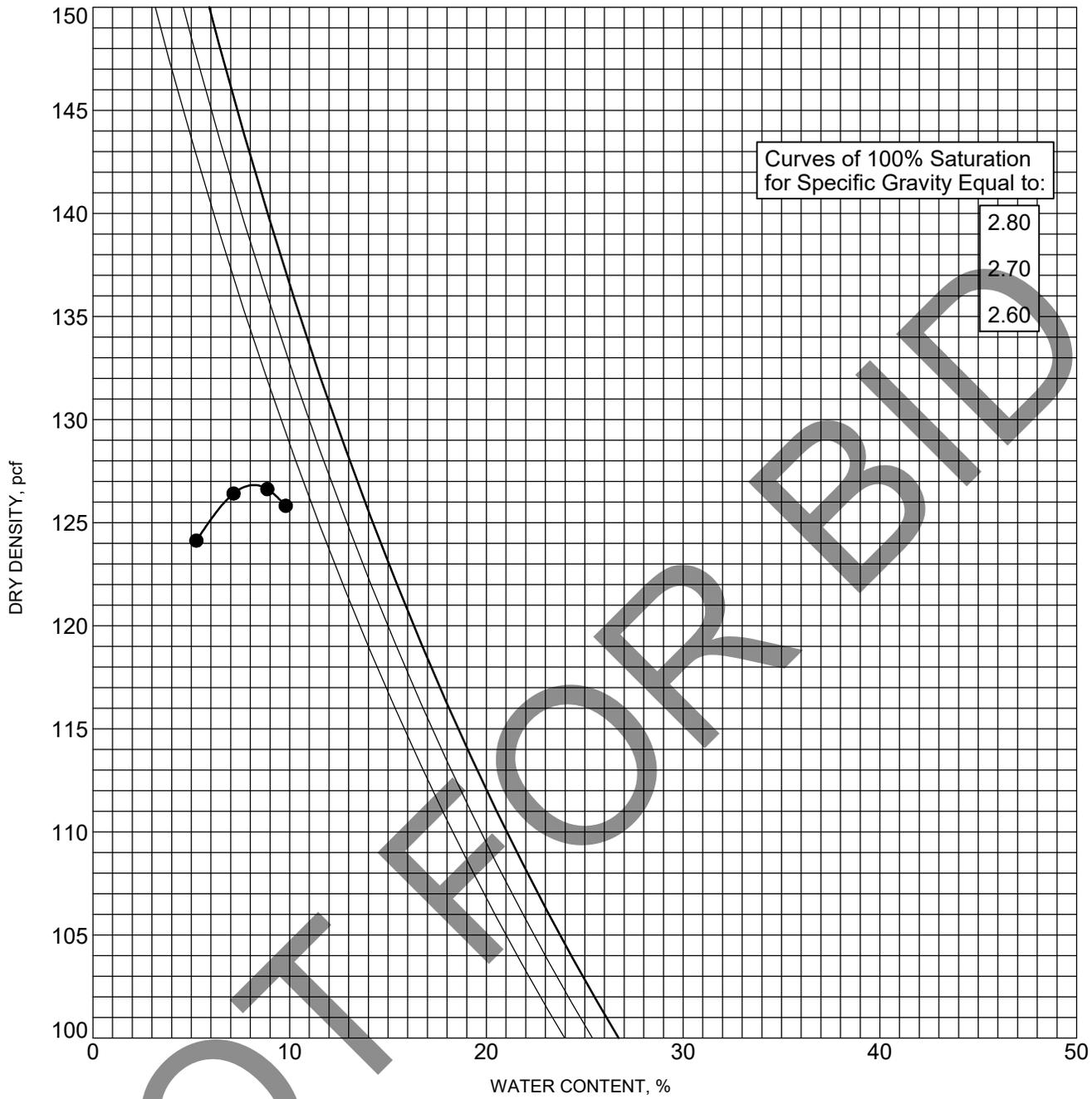
**Consolidation Testing:** Two samples were selected for consolidation testing in accordance with ASTM D2435. This test is used to evaluate the magnitude and rate of settlement of a structure or earth fill. The results of this testing are presented graphically on Figure B-6.

**Direct Shear Strength:** Two samples were selected and transported to AP Engineering and Testing in Pomona, California for direct shear strength testing in accordance with ASTM D3080. This testing measures the shear strength of the soil under various normal pressures and is used to develop parameters for foundation bearing capacity and lateral earth pressure. Test results are shown on Figures B-7 and B-8.

**Corrosion Testing:** One sample was selected and transported to AP Engineering and Testing in Pomona, California to evaluate the concentration of soluble sulfates and chlorides, pH level, and resistivity of and within the on-site soils. The test results are shown on Figure B-9.

**R-value:** One sample was selected for R-value and delivered to Terracon in Colton, California for testing in accordance with ASTM D2844. This test measures the potential strength of subgrade, subbase, and base course materials for use in pavements. Test results are shown on Figure No. B-10.

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BOREHOLE	DEPTH	Description of Materials	Max DD	Optimum WC
● B-01	0.0	SILTY SAND with GRAVEL(SM)	126.8 PCF	8.1 %

**INLAND FOUNDATION ENGINEERING, INC.**

**MOISTURE-DENSITY CURVES (ASTM D1557)**

FIGURE NO. B-3

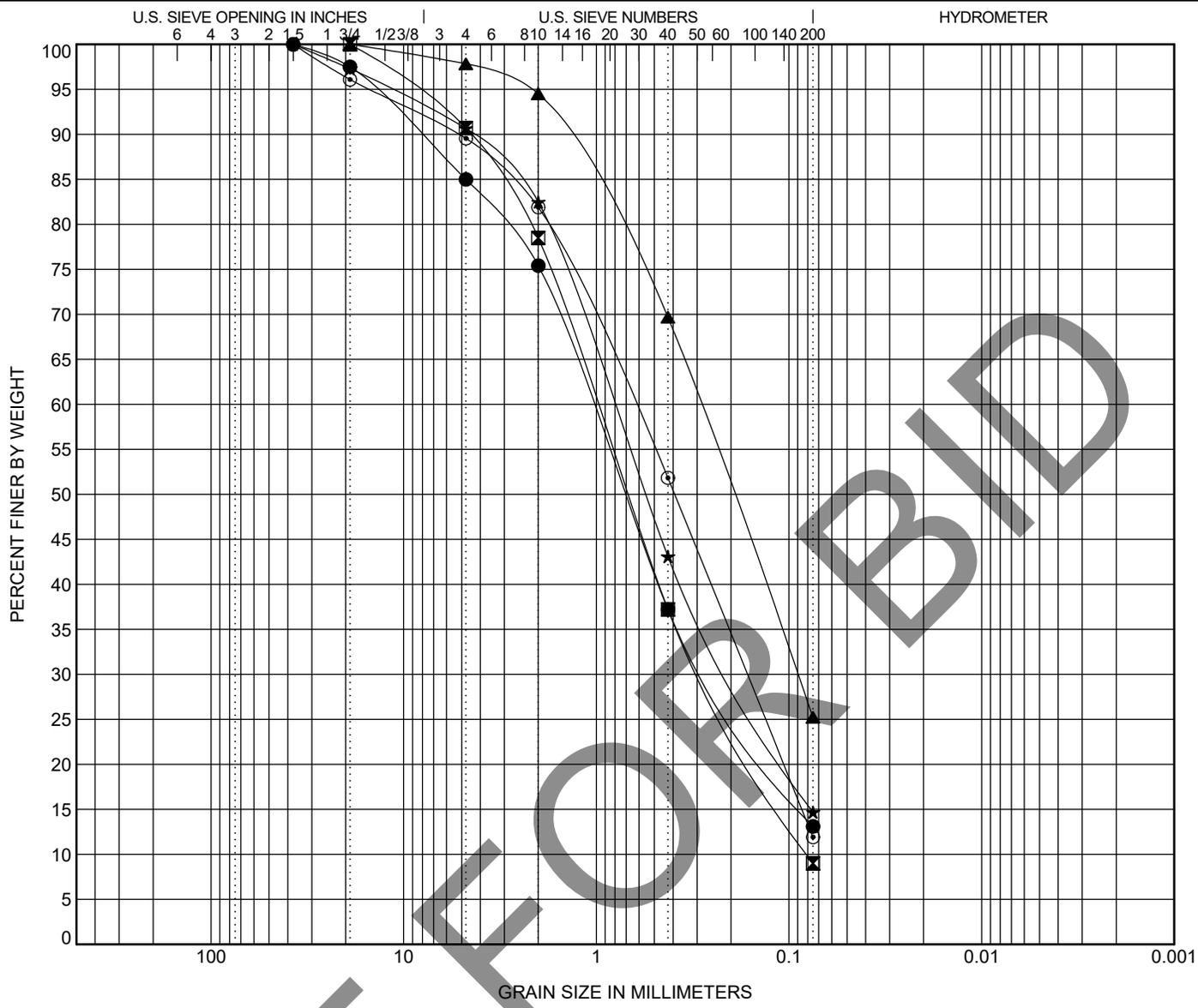
CLIENT STK Architecture, Inc.

PROJECT NAME Fire Station #227

PROJECT NUMBER S168-193

PROJECT LOCATION NWC Genevieve St. & W. 38th St.

San Bernardino, CA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SAMPLE	DEPTH	Classification	LL	PL	PI	Cc	Cu		
● B-01	0.0	SILTY SAND with GRAVEL(SM)	NP	NP	NP				
☒ B-01	4.5	POORLY GRADED SAND with SILT(SP-SM)	NP	NP	NP	0.93	12.53		
▲ B-02	0.3	SILTY SAND(SM)	NP	NP	NP				
★ B-02	8.0	SILTY SAND(SM)	NP	NP	NP				
◎ B-02	12.5	POORLY GRADED SAND with SILT(SP-SM)	NP	NP	NP	0.61	9.38		
BOREHOLE	DEPTH	D100	D90	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-01	0.0	37.5	8.278	0.714		15.0	71.9		13.1
☒ B-01	4.5	19	4.517	0.687	0.08	9.3	81.7		9.0
▲ B-02	0.3	19	1.51	0.197		2.2	72.6		25.2
★ B-02	8.0	37.5	4.43	0.558		9.3	76.0		14.7
◎ B-02	12.5	37.5	5.223	0.393		10.4	77.6		11.9

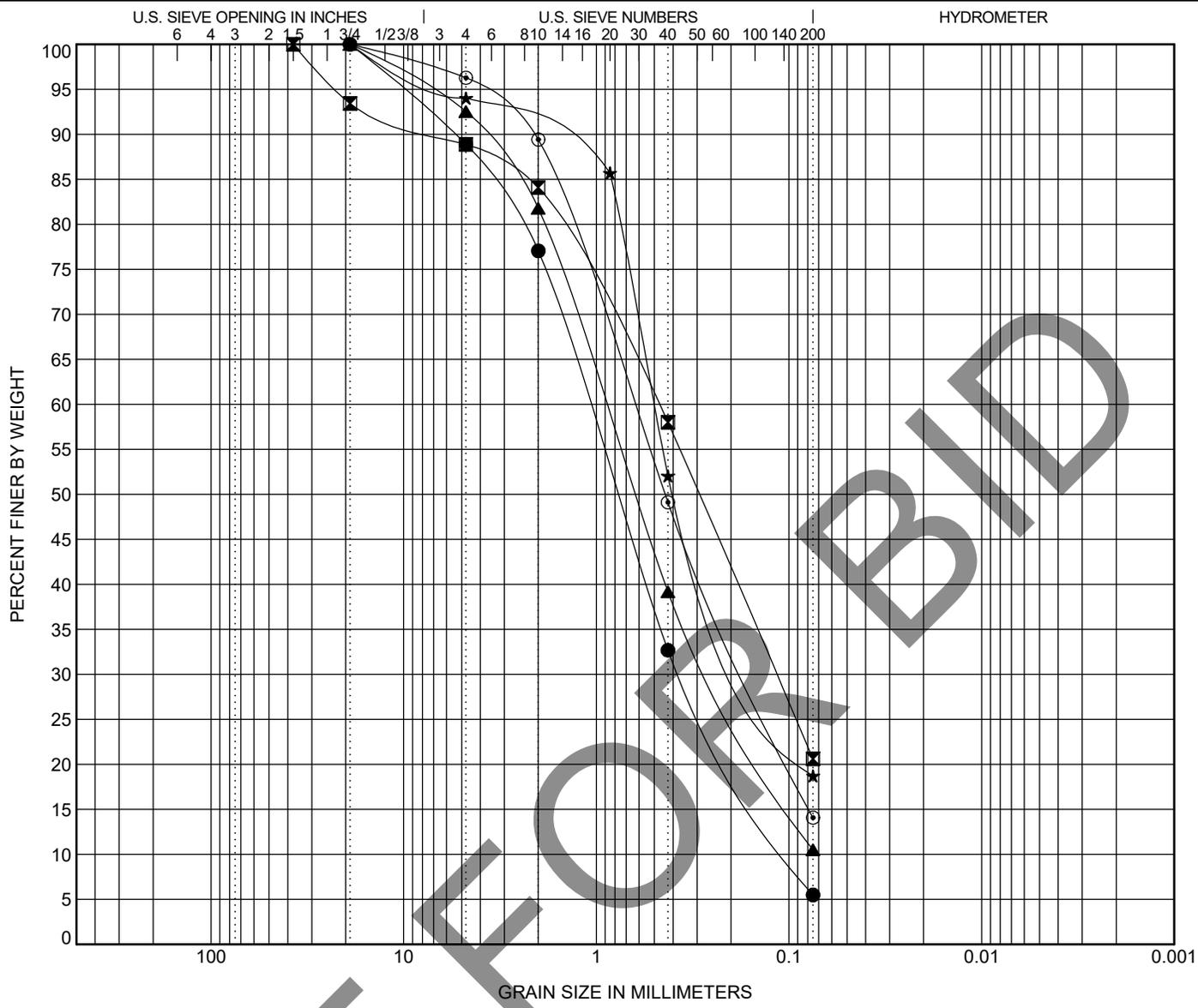
GRADATION CURVES (ASTM D6913, ASTM D4318)

INLAND FOUNDATION ENGINEERING, INC.

FIGURE NO. B-4

CLIENT STK Architecture, Inc. PROJECT NAME Fire Station #227  
 PROJECT NUMBER S168-193 PROJECT LOCATION NWC Genevieve St. & W. 38th St.  
San Bernardino, CA

IFE SIEVE ANALYSIS - GINT STD US LAB.GDT - 8/20/24 15:29 - P:\S168\S168-193 SB FS 227\GINT.GPJ



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SAMPLE	DEPTH	Classification	LL	PL	PI	Cc	Cu		
● B-02	20.5	WELL-GRADED SAND with SILT(SW-SM)	NP	NP	NP	1.16	11.03		
☒ B-03	0.3	SILTY SAND(SM)	NP	NP	NP				
▲ B-03	7.8	POORLY GRADED SAND with SILT(SP-SM)	NP	NP	NP	0.90	12.46		
★ B-04	0.3	SILTY SAND(SM)	NP	NP	NP				
◎ B-04	2.0	SILTY SAND(SM)	NP	NP	NP				
BOREHOLE	DEPTH	D100	D90	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-02	20.5	19	5.451	0.778	0.1	11.1	83.4	5.5	
☒ B-03	0.3	37.5	6.699	0.293		11.1	68.2	20.6	
▲ B-03	7.8	19	3.874	0.63		7.5	82.0	10.5	
★ B-04	0.3	19	2.069	0.382		6.0	75.3	18.7	
◎ B-04	2.0	19	2.151	0.44		3.7	82.2	14.1	

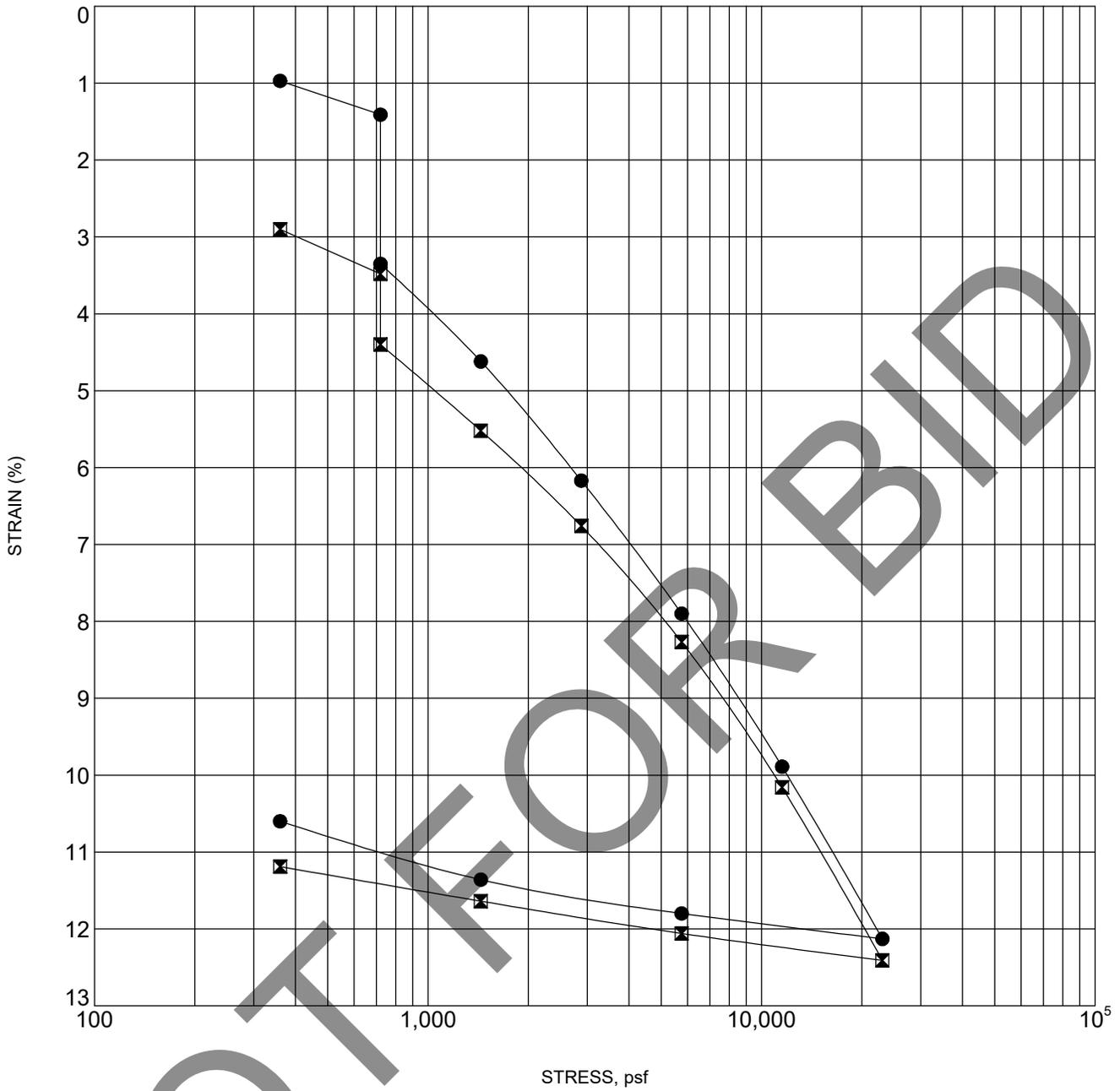
GRADATION CURVES (ASTM D6913, ASTM D4318)

INLAND FOUNDATION ENGINEERING, INC.

FIGURE NO. B-5

CLIENT STK Architecture, Inc. PROJECT NAME Fire Station #227  
 PROJECT NUMBER S168-193 PROJECT LOCATION NWC Genevieve St. & W. 38th St.  
San Bernardino, CA

IFE SIEVE ANALYSIS - GINT STD US LAB.GDT - 8/20/24 15:29 - P:\S168\S168-193 SB FS 227\GINT.GPJ



BOREHOLE	DEPTH	Classification	$\gamma_d$	MC%
● B-02	6.5			
☒ B-03	5.5			

**CONSOLIDATION TEST (ASTM D2435)**

**INLAND FOUNDATION ENGINEERING, INC.**

FIGURE NO. B-6

<b>CLIENT</b>	<u>STK Architecture, Inc.</u>	<b>PROJECT NAME</b>	<u>Fire Station #227</u>
<b>PROJECT NUMBER</b>	<u>S168-193</u>	<b>PROJECT LOCATION</b>	<u>NWC Genevieve St. &amp; W. 38th St.</u>
			<u>San Bernardino, CA</u>

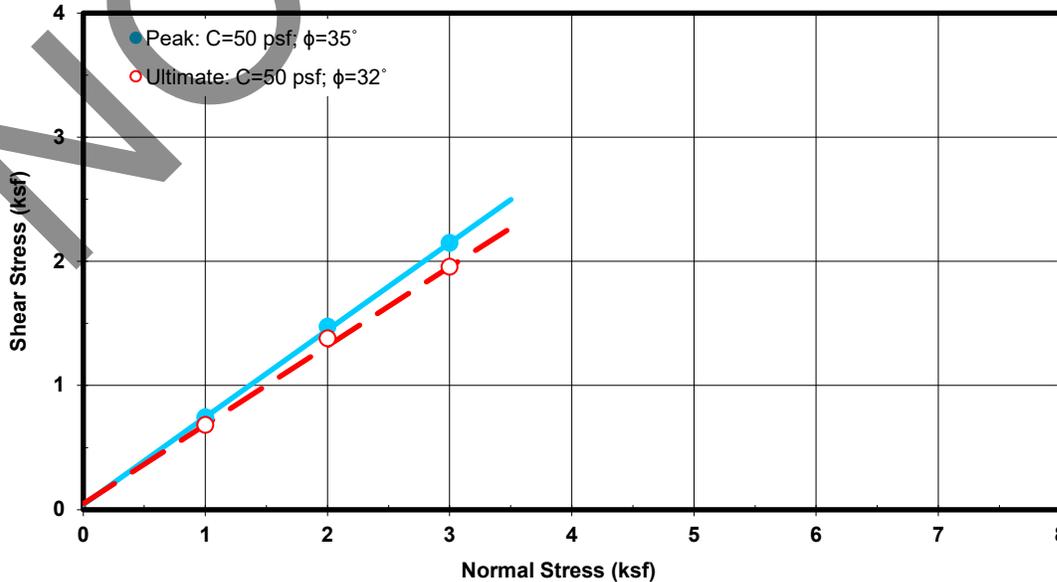
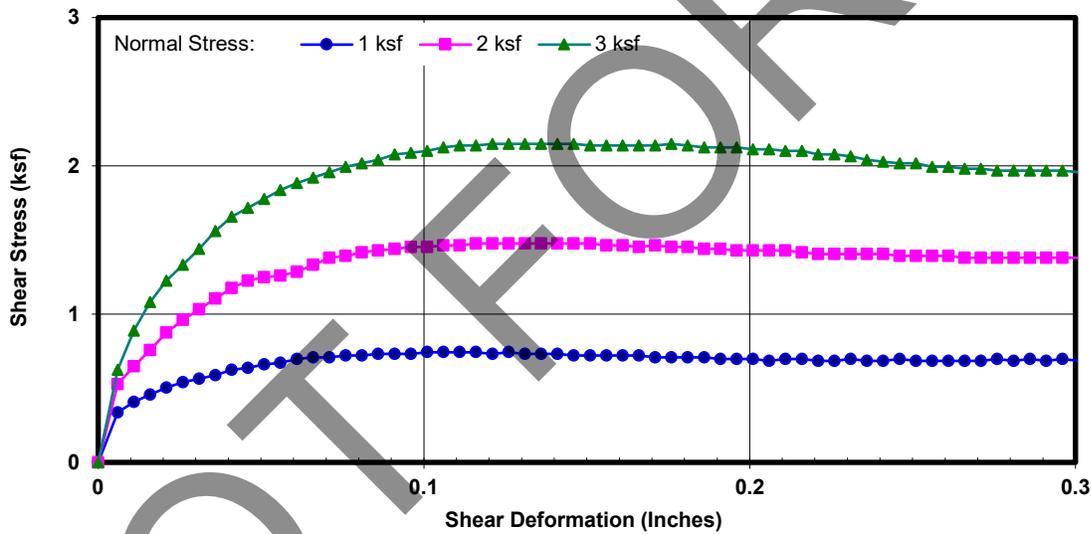


**DIRECT SHEAR TEST RESULTS**  
**ASTM D 3080**

**Project Name:** STK - Fire Station 227  
**Project No.:** 5163-193  
**Boring No.:** B-02  
**Sample No.:** - **Depth (ft):** 3.5-4.5  
**Sample Type:** Mod. Cal.  
**Soil Description:** Silty Sand  
**Test Condition:** Inundated **Shear Type:** Regular

**Tested By:** ST **Date:** 08/02/24  
**Computed By:** JP **Date:** 08/07/24  
**Checked by:** AP **Date:** 08/07/24

Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Initial Moisture Content (%)	Final Moisture Content (%)	Initial Degree Saturation (%)	Final Degree Saturation (%)	Normal Stress (ksf)	Peak Shear Stress (ksf)	Ultimate Shear Stress (ksf)
110.0	106.4	3.4	19.3	16	89	1	0.744	0.684
						2	1.476	1.380
						3	2.148	1.956



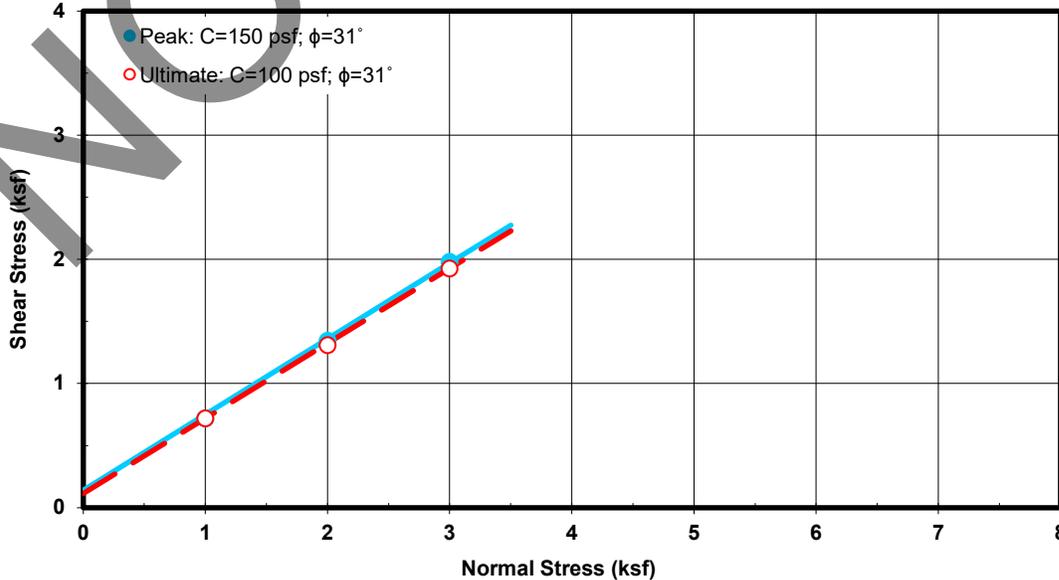
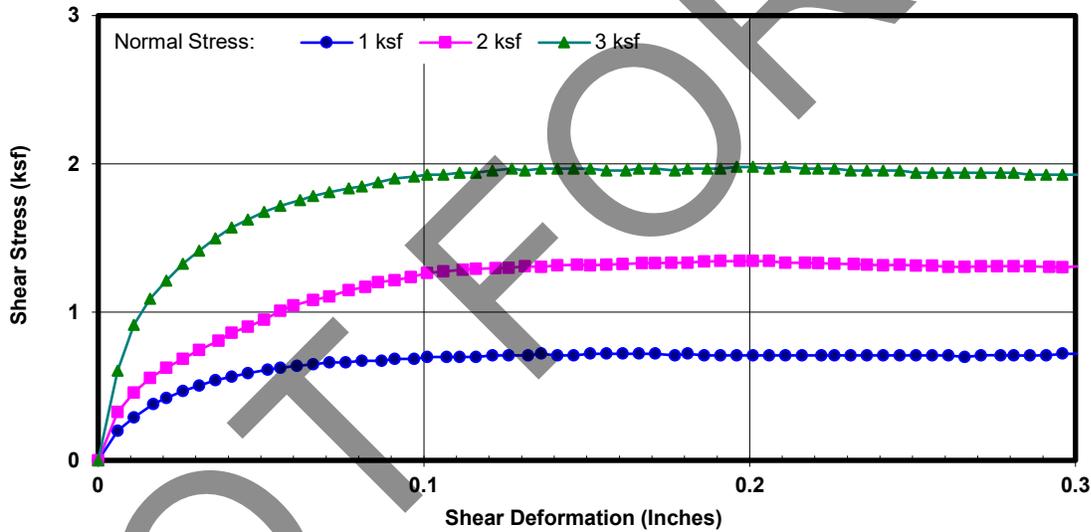


### DIRECT SHEAR TEST RESULTS ASTM D 3080

**Project Name:** STK - Fire Station 227  
**Project No.:** 5163-193  
**Boring No.:** B-03  
**Sample No.:** - **Depth (ft):** 2.5-3.5  
**Sample Type:** Mod. Cal.  
**Soil Description:** Silty Sand  
**Test Condition:** Inundated **Shear Type:** Regular

**Tested By:** ST **Date:** 08/02/24  
**Computed By:** JP **Date:** 08/07/24  
**Checked by:** AP **Date:** 08/07/24

Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Initial Moisture Content (%)	Final Moisture Content (%)	Initial Degree Saturation (%)	Final Degree Saturation (%)	Normal Stress (ksf)	Peak Shear Stress (ksf)	Ultimate Shear Stress (ksf)
106.1	102.4	3.6	21.0	15	88	1	0.720	0.720
						2	1.344	1.308
						3	1.980	1.927





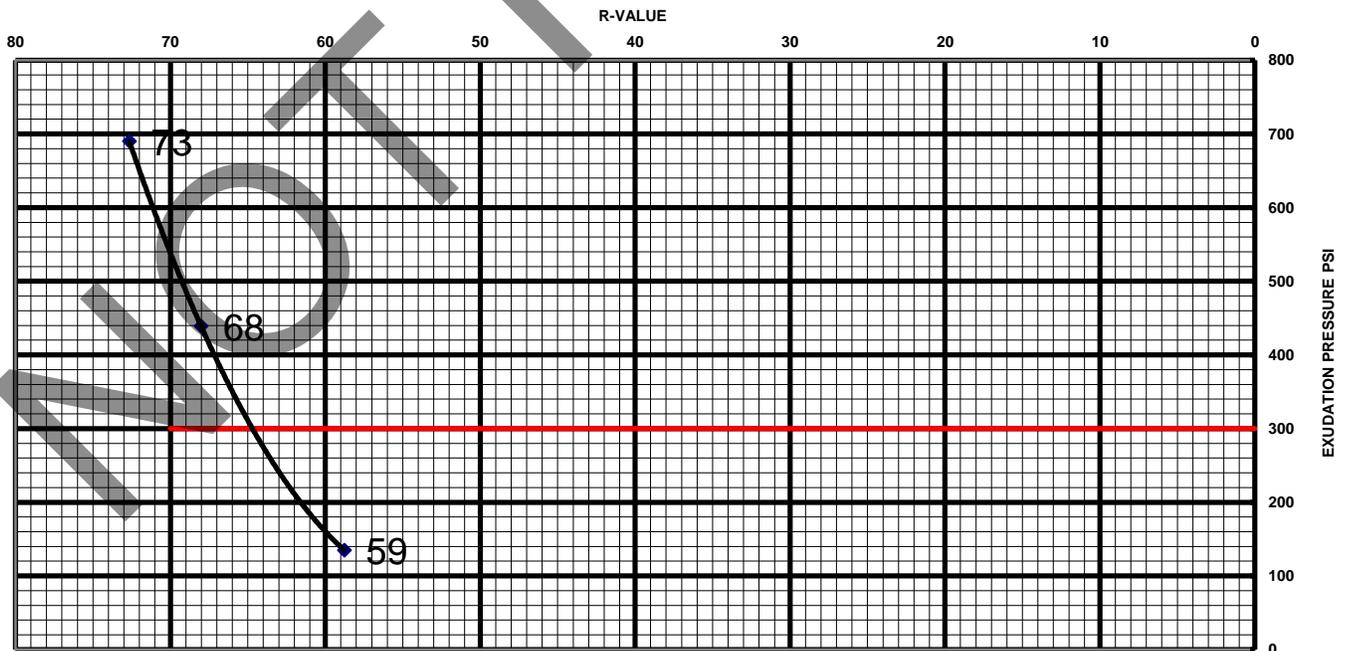
**LABORATORY RECORD OF TESTS MADE ON  
 BASE, SUBBASE, AND BASEMENT SOILS**

**CLIENT:** Inland Foundation Engineering  
**PROJECT** STK-Fire Station 227 S168-193  
**LOCATION:**  
**R-VALUE # :** B-03  
**T.I. :**

COMPACTOR AIR PRESSURE P.S.I.  
 INITIAL MOISTURE %  
 WATER ADDED, ML  
 WATER ADDED %  
 MOISTURE AT COMPACTION %  
 HEIGHT OF BRIQUETTE  
 WET WEIGHT OF BRIQUETTE  
 DENSITY LB. PER CU.FT.  
 STABILOMETER PH AT 1000 LBS.  
 2000 LBS.  
 DISPLACEMENT  
 R-VALUE  
 EXUDATION PRESSURE  
 THICK. INDICATED BY STAB.  
 EXPANSION PRESSURE  
 THICK. INDICATED BY E.P.

	A	B	C	D
COMPACTOR AIR PRESSURE P.S.I.	350	350	350	
INITIAL MOISTURE %	3.7	3.7	3.7	
WATER ADDED, ML	70	60	50	
WATER ADDED %	6.6	5.6	4.7	
MOISTURE AT COMPACTION %	10.3	9.3	8.4	
HEIGHT OF BRIQUETTE	2.48	2.50	2.50	
WET WEIGHT OF BRIQUETTE	1106	1107	1106	
DENSITY LB. PER CU.FT.	122.6	122.7	123.7	
STABILOMETER PH AT 1000 LBS.	23	18	16	
2000 LBS.	38	29	26	
DISPLACEMENT	5.63	5.31	4.85	
R-VALUE	59	68	73	
EXUDATION PRESSURE	135	439	690	
THICK. INDICATED BY STAB.	0.00	0.00	0.00	
EXPANSION PRESSURE	0	0	0	
THICK. INDICATED BY E.P.	0.00	0.00	0.00	

**EXUDATION CHART**



**R-Value: 64**

NOT FOR BID

## APPENDIX C

### INFILTRATION TESTING

Infiltration testing was conducted in general accordance with Appendix D of the Technical Guidance Document for Water Quality Management Plans for the County of San Bernardino Areawide Stormwater Program (2013). The shallow percolation test method was used per the Riverside County Department of Environmental Health guidelines. The percolation rates were converted to infiltration rates using the Porchet method.

Four percolation tests were performed at the locations shown on Figure A-2. The test holes were drilled on July 11, 2024 to depths of approximately 4 and 5 feet below existing ground surface. The test holes were approximately eight (8) inches in diameter. Gravel was placed in the bottom of each test hole. The test holes were then pre-soaked by inverting 5-gallons of water above the test hole.

Testing was conducted 24 hours after the pre-soak on July 12, 2024. All pre-soak water had percolated through the test holes. For all tests, more than 6 inches of water seeped away twice consecutively in less than 25 minutes, which meets the sandy soil criteria. The tests were then run for an additional hour with measurements taken every 10 minutes.

The water percolated through all test holes within all 10-minute test intervals. The percolation rates were calculated to range from 1.0 to 2.5 minutes per inch (mpi). The percolation test rate was converted to an infiltration rate ( $I_c$ ) using the Porchet method and the following equation:

$$I_c = \Delta H 60r / \Delta t (r + 2H_{avg})$$

Where:

$r$  = Test Hole Radius (in.)

$H_{avg}$  = Average Height of Water during Test Interval (in.)

$\Delta H$  = Change in Water Height during Test Interval (in.), and

$\Delta t$  = Time Interval (in.)

The corresponding calculated infiltration rates ( $I_c$ ) ranged from 2.0 to 5.7 inches per hour. These values exclude a factor of safety. Copies of the field test sheets are included with this report as Figures C-2 through C-5.

## PERCOLATION TEST DATA SHEET – INFILTRATION TESTING

Project: Fire Station 227			Project No.: S168-193			Date: 7/12/2024			
Test Hole No.: P-01			Tested By: Floyd Collins						
Depth of Test Hole (D <sub>T</sub> ): 60"			USCS Soil Classification: SM						
Test Hole Dimensions (inches)				Length			Width		
Diameter (if round)= 8"			Sides (if rectangular) =						
<b>Sandy Soil Criteria Test*</b>									
Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6" (Y/N)		
1	6:59	7:24	25	31	58	27	Y		
2	7:25	7:50	25	36	58	22	Y		
3									
<p>*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Otherwise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".</p>									
Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D <sub>o</sub> Initial Depth to Water (in.)	D <sub>f</sub> Final Depth to Water (in.)	ΔD=ΔH Change in Water Level (in.)	Perc. Rate min./in.	H <sub>Avg</sub> (D <sub>T</sub> - D <sub>o</sub> ) + (D <sub>T</sub> - D <sub>f</sub> ) ÷ 2	I <sub>T</sub> ΔH 60r / Δt(r+2H) Avg
1	7:51	8:01	10	36	51	15	.67	16.5	9.7
2	8:02	8:12	10	36	48.5	12.5	.80	17.8	7.6
3	8:13	8:23	10	36	47	11	.91	18.5	6.4
4	8:24	8:34	10	36	46	10	1.0	19	5.7
5	8:35	8:45	10	36	46	10	1.0	19	5.7
6	8:47	8:57	10	36	46	10	1.0	19	5.7
7									
8									
9									
10									
11									
12									
13									
14									
15									
<p><b>COMMENTS: Presoaked hole on 7/11/2024. Dry hole next day. First two measurements met sandy soil criteria. Overcast (75°)</b></p>									

## PERCOLATION TEST DATA SHEET – INFILTRATION TESTING

Project: Fire Station 227			Project No.: S168-193			Date: 7/12/2024			
Test Hole No.: P-02			Tested By: Floyd Collins						
Depth of Test Hole (D <sub>T</sub> ): 48"			USCS Soil Classification: SM						
Test Hole Dimensions (inches)				Length			Width		
Diameter (if round)= 8"			Sides (if rectangular) =						
<b>Sandy Soil Criteria Test*</b>									
Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6" (Y/N)		
1	7:03	7:28	25	24	46	22	Y		
2	7:29	7:54	25	24	45.5	21.5	Y		
3									
<p>*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Otherwise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".</p>									
Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D <sub>o</sub> Initial Depth to Water (in.)	D <sub>f</sub> Final Depth to Water (in.)	ΔD=ΔH Change in Water Level (in.)	Perc. Rate min./in.	H <sub>Avg</sub> (D <sub>T</sub> - D <sub>o</sub> ) + (D <sub>T</sub> - D <sub>f</sub> ) ÷ 2	I <sub>T</sub> ΔH 60r / Δt(r+2H) Avg
1	8:59	9:09	10	24	36	12	.83	18	7.2
2	9:10	9:20	10	24	34.5	11.5	.87	18.8	6.0
3	9:20	9:30	10	24	34.5	11.5	.87	18.8	6.0
4	9:31	9:41	10	24	34	10	1.0	19	5.7
5	9:42	9:52	10	24	34	10	1.0	19	5.7
6	9:53	10:03	10	24	34	10	1.0	19	5.7
7									
8									
9									
10									
11									
12									
13									
14									
15									
<p><b>COMMENTS: Presoaked hole on 7/11/2024. Dry hole next day. First two measurements met sandy soil criteria. Overcast (77°F)</b></p>									

## PERCOLATION TEST DATA SHEET – INFILTRATION TESTING

Project: Fire Station 227			Project No.: S168-193			Date: 7/12/2024			
Test Hole No.: P-03			Tested By: Floyd Collins						
Depth of Test Hole (D <sub>T</sub> ): 60"			USCS Soil Classification: SM						
Test Hole Dimensions (inches)				Length			Width		
Diameter (if round)= 8"			Sides (if rectangular) =						
<b>Sandy Soil Criteria Test*</b>									
Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6" (Y/N)		
1	7:06	7:31	25	35	46	11	Y		
2	7:32	7:57	25	36	45	9	Y		
3									
<p>*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Otherwise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".</p>									
Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D <sub>o</sub> Initial Depth to Water (in.)	D <sub>f</sub> Final Depth to Water (in.)	ΔD=ΔH Change in Water Level (in.)	Perc. Rate min./in.	H <sub>Avg</sub> (D <sub>T</sub> - D <sub>o</sub> ) + (D <sub>T</sub> - D <sub>f</sub> ) ÷ 2	I <sub>T</sub> ΔH 60r / Δt(r+2H) Avg
1	10:04	10:14	10	36	40	4	2.5	22	2.0
2	10:15	10:25	10	36	40	4	2.5	22	2.0
3	10:26	10:36	10	36	40	4	2.5	22	2.0
4	10:37	10:47	10	36	40	4	2.5	22	2.0
5	10:48	10:58	10	36	40	4	2.5	22	2.0
6	10:59	11:09	10	36	40	4	2.5	22	2.0
7									
8									
9									
10									
11									
12									
13									
14									
15									
<p><b>COMMENTS: Presoaked hole on 7/11/2024. Dry hole next day. First two measurements met sandy soil criteria. Partly Cloudy (83°F)</b></p>									

## PERCOLATION TEST DATA SHEET – INFILTRATION TESTING

Project: Fire Station 227			Project No.: S168-193			Date: 7/12/2024			
Test Hole No.: P-04			Tested By: Floyd Collins						
Depth of Test Hole (D <sub>T</sub> ): 48"			USCS Soil Classification: SM						
Test Hole Dimensions (inches)				Length			Width		
Diameter (if round)= 8"			Sides (if rectangular) =						
<b>Sandy Soil Criteria Test*</b>									
Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6" (Y/N)		
1	7:07	7:32	25	24	46	22	Y		
2	7:33	7:58	25	24	45	21	Y		
3									
<p>*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Otherwise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".</p>									
Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D <sub>o</sub> Initial Depth to Water (in.)	D <sub>f</sub> Final Depth to Water (in.)	ΔD=ΔH Change in Water Level (in.)	Perc. Rate min./in.	H <sub>Avg</sub> (D <sub>T</sub> - D <sub>o</sub> ) + (D <sub>T</sub> - D <sub>f</sub> ) ÷ 2	I <sub>T</sub> ΔH 60r / Δt(r+2H) Avg
1	11:09	11:19	10	24	36	12	.83	18	7.2
2	11:20	11:30	10	24	35	11	.91	18.5	6.4
3	11:31	11:41	10	24	34.5	10.5	.95	18.8	6.0
4	11:42	11:52	10	24	34	10	1.0	19	5.7
5	11:53	12:03	10	24	34	10	1.0	19	5.7
6	12:04	12:14	10	24	34	10	1.0	19	5.7
7									
8									
9									
10									
11									
12									
13									
14									
15									
<p><b>COMMENTS:</b> Presoaked hole on 7/11/2024. Dry hole next day. First two measurements met sandy soil criteria. Partly cloudy (89°F)</p>									

**APPENDIX D –  
Liquefaction and Seismic  
Settlement Analysis**

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NOT FOR BID

## APPENDIX D

### LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS

Liquefaction and seismic settlement potential were evaluated using the GeoSuite® computer program (version 3.2.1.6). The seismic parameters included a horizontal acceleration of 0.95g and a Moment Magnitude of 8.1. We analyzed the soil profile logged for exploratory boring B-02. The GeoSuite® program calculates corrected normalized SPT N-values  $(N_1)_{60}$  using the following formula (SCEC, 1999).

$$(N_1)_{60} = N_M C_N C_E C_B C_R C_S$$

Where;  $N_M$  = measured standard penetration resistance. Modified California sample blowcounts were converted to SPT blowcounts using Burmister's formula (1948) prior to input in the program. The modified California sample blowcounts were also corrected to account for lined samplers, as described in the  $C_S$  factor discussion below.

$C_N$  = depth correction factor. GeoSuite® calculates  $C_N$  for each layer in the soil profile using the relationship suggested by Idriss and Boulanger (2008)

$C_E$  = hammer energy ratio (ER) correction factor. A  $C_E$  factor of 1.3 was applied for the automatic trip hammer used during drilling and was calculated using the relationship suggested by Idriss and Boulanger (2008).

$C_B$  = borehole diameter correction factor. A  $C_B$  factor of 1.0 was applied for the 8-inch diameter hollow-stem augers with inside diameters of four (4) inches (SCEC 1999).

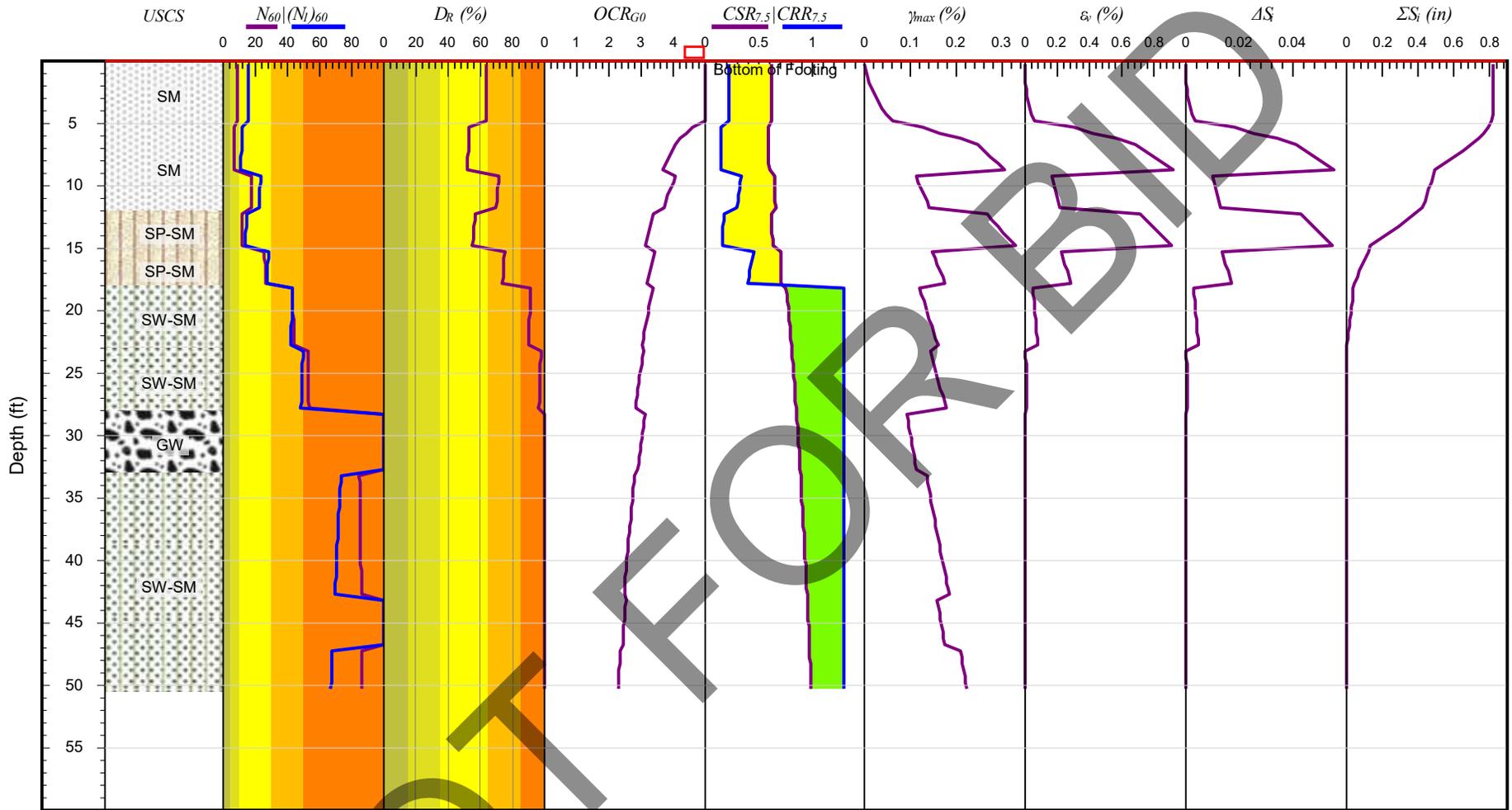
$C_R$  = rod length correction factor. GeoSuite® applies a  $C_R$  factor for each layer in the soil profile using the values in Table 5.2 of the 1999 SCEC guidelines, and assuming a rod stick up length (above the ground surface) of 3 feet.

$C_S$  = correction factor for samplers with or without liners. SPT samplers without liners were used for this project. For SPT samplers without liners, GeoSuite® applies a  $C_S$  factor for each layer in the soil profile using the relationships from Seed et al. (1984) and suggested by Idriss and Boulanger (2008). Since GeoSuite® applies a  $C_S$  factor to all layers in the soil profile, it is necessary to adjust blowcounts for modified California samplers with liners.

This was done through an iterative process by initially dividing the modified California sampler blowcounts by an assumed  $C_S$  value of 1.2 prior to input in the program.

Calculated  $C_S$  values were then checked against the assumed values and adjusted where necessary, so that the actual applied  $C_S$  value for modified California samples is 1.0.

The results of the analysis are shown on Figure D-2.



Silt Correction:  
UCLA method

Earthquake & Groundwater Information:  
 Magnitude = 8.1  
 Max. Acceleration = 0.95 g  
 Project GW = 100 ft  
 Maximum Settlement = 0.82 in  
 Settl. at Bottom of Footing = 0.82 in

Liquefaction: Boulanger & Idriss (2010-16)  
 Settl.: [dry] Yi (2022)  
 Lateral spreading: Idriss & Boulanger (2008)  
 M correction: [Sand] Boulanger & Idriss(2004)  
 $\sigma_v$  correction: Idriss & Boulanger (2008)  
 Stress reduction: Idriss & Boulanger (2008)

**Seismic Settlement Potential - SPT Data**

Project:	Fire Station 227			
Location:	Genevieve and 38th			
Project No.:	S168-193	Boring No.:	B-02	Figure:
				0



NOT FOR BID



**GEOLOGIC HAZARDS REPORT  
SAN BERNARDINO COUNTY FIRE STATION 227  
NWC OF 38<sup>TH</sup> STREET AND GENEVIEVE AVENUE  
CITY OF SAN BERNARDINO, CALIFORNIA**

Project No. 244073-1

July 20, 2024

**Prepared for:**

Inland Foundation Engineering, Inc.  
1310 South Santa Fe Avenue  
San Jacinto, CA 92583

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**Consulting Engineering Geology & Geophysics**

**P.O. Box 1090, Loma Linda, CA 92354 • 909 796-4667**

Inland Foundation Engineering, Inc.  
1310 South Santa Fe Avenue  
San Jacinto, CA 92583

Attention: Mr. Allen Evans, P.E., G.E., Principal

Regarding: Geologic Hazards Report  
San Bernardino County Fire Station 227  
NWC of 38<sup>th</sup> Street and Genevieve Avenue  
City of San Bernardino, California  
IFE Project No. S168-193

At your request, this firm has prepared a geologic hazards report for the proposed new San Bernardino County Fire Station 227, as referenced above. The purpose of this study was to evaluate the existing geologic conditions of the property and any corresponding potential geologic and/or seismic hazards, with respect to the proposed development from a geologic standpoint. This report has been prepared utilizing the suggested "Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings" (CGS Note 48, 2022).

The scope of services provided for this evaluation included the following:

- **Review of available published and unpublished geologic/seismic data in our files pertinent to the site, including the provided site-specific boring logs.**
- **Performing a seismic surface-wave survey by a licensed State of California Professional Geophysicist that included one traverse for shear-wave velocity analysis purposes.**
- **Evaluation of the local and regional tectonic setting and historical seismic activity, including performing a site-specific CBC ground motion analysis.**
- **Preparation of this report presenting our findings, conclusions, and recommendations from a geologic standpoint.**

#### **Accompanying Maps and Appendices**

- Plate 1 - Regional Geologic Map
- Plate 2 - Google™ Earth Imagery Map
- Plate 3 - Site Plan
- Appendix A - Shear-Wave Survey
- Appendix B - Site-Specific Ground Motion Analysis
- Appendix C - References

## **PROJECT SUMMARY**

We understand that this report will be appended to your current geotechnical investigation, therefore, some descriptive sections such as site description, proposed development, etc., have been purposely omitted as they have been described in detail in your referenced report. No grading plans were available for this evaluation, and no field or subsurface exploration was performed by this firm. Only a review of available geologic and geotechnical data in our files was undertaken, including observation of the exploratory borings that were drilled by Inland Foundation engineering, Inc. (IFE) on July 11, 2024, including performing a seismic shear-wave survey.

## **GEOLOGIC SETTING**

The subject site lies within a natural geomorphic province in California known as the Peninsular Ranges. This province is characterized by northwest-trending valleys and mountains that are, in part, due to the tectonic framework of this area, which is also dominated by a northwest-trending structure. Locally, the study area is included within a sub-structural unit of the Peninsular Ranges known as the San Bernardino Valley Block. This block is essentially a depressed region bounded by faults to the northeast (San Andreas), the southwest (San Jacinto), and the south (Banning).

The San Bernardino Valley is formed by a series of coalescing alluvial fans, of which the combined fan of the Santa Ana River and Mill Creek, originating from to the northeast, is the largest and most distinct. This and other alluvial fans (i.e., Lytle and Cajon Creeks, Devil Canyon, East Twin and City Creeks) emanate the mountains, then coalesce to form part of a broad alluvial plain, which then forms the San Bernardino Valley.

The subject area investigated for this report is included within the flood/alluvial plain limits of the San Bernardino Valley, situated near the eastern flank of Little Mountain, which is a low-lying bedrock hill that locally protrudes from the San Bernardino Valley. Geologic mapping of the area by Miller et al. (2001), as illustrated on Plate 1, indicates that the project development area is locally underlain by both slightly- to moderately consolidated early Holocene and late Pleistocene alluvial fan deposits (map symbol Qyf<sub>1</sub>), generally described as sand and pebble-boulder gravel, along with late Holocene age very young wash deposits (map symbol Qw), consisting of unconsolidated to locally cemented sand, gravel, and boulder deposits. Relatively older and more consolidated alluvial deposits are presumed to underlie the subject site at depth.

The exploratory boring logs prepared by IFE (2024) indicate that the subject site is underlain predominantly by interbedded fine- to medium-grained silty sand, fine- to coarse-grained sand with silt, fine- to coarse-grained sand, and gravel with fine- to coarse-grained sand, along with gravel and cobbles throughout. These alluvial deposits were noted to be in a generally loose to very dense condition, to a depth of at least 50½ feet locally.

## **FAULTING**

There are at least forty-three major late Quaternary active/potentially active faults that are located within a 100-kilometer (62-mile) radius of the subject site (Blake, 1989-2000). Of these, there are no known active faults that traverse the site based on available published literature, nor was there any surficial geomorphic evidence that was suggestive of faulting. Additionally, the subject site is not located within a State of California "Alquist-Priolo Earthquake Fault Zone" for surface-fault rupture hazard (California Division of Mines and Geology, 1974).

The nearest known "active" fault that is zoned by the California Geological Survey is the San Andreas Fault (San Bernardino North Segment), located approximately  $1.1 \pm$  miles to the northeast (C.D.M.G., 1974), as shown on the Regional Geologic Map, Plate 1, for reference. This fault segment is a right-lateral, strike-slip fault, being approximately 103-kilometers in length, with an associated maximum moment magnitude ( $M_w$ ) of 7.4 and a slip-rate of  $24 \pm 6$  mm/year (C.D.M.G., 1996, Cao, et al., 2003, and Petersen et al., 2008).

However, for seismic design purposes, we are considering that a cascading effect of rupture will occur along the entire length of the southern San Andreas Fault Zone (which includes ten segments, collectively) rather than just the San Bernardino North segment. Based on the recently published rupture-model data (Petersen et al., 2008), the total rupture area of these combined faults is 6,849.7 square kilometers and has an associated Maximum Moment Magnitude ( $M_w$ ) of 8.1.

## **GROUND MOTION ANALYSIS**

According to California Geological Survey Note 48 (CGS, 2022), a site-specific ground motion analysis is required for the subject site (CBC, 2022, Section 1613A and also as required by ASCE 7-16, Chapter 21). The results of this analysis are presented within Appendix B for documentation purposes. Additionally, a seismic shear-wave survey was conducted for this study by our firm as presented within Appendix A of this report for purposes of determining the soil Site Classification and  $V_{s30}$  input values for the ground motion analysis. This survey was performed within the limits of the proposed construction.

Geographically, the subject construction area is centrally located at Latitude 34.1601 and Longitude -117.2866 and (World Geodetic System of 1984 coordinates). The mapped spectral acceleration parameters, coefficients, and other related seismic parameters, were evaluated using the California's Office of Statewide Health Planning and Development Seismic Design Maps (OSHPD, 2024) and the California Building Code criteria (CBC, 2022), with the site-specific ground motion analysis being performed following Section 21 of the ASCE 7-16 Standard (2017). The results of this site-specific analysis have been summarized and are tabulated below:

**TABLE 1 – SUMMARY OF SEISMIC DESIGN PARAMETERS**

Factor or Coefficient	Value
<b>S<sub>s</sub></b>	<b>2.506g</b>
<b>S<sub>1</sub></b>	<b>1.002g</b>
<b>F<sub>a</sub></b>	<b>1.2</b>
<b>F<sub>v</sub></b>	<b>1.7</b>
<b>S<sub>DS</sub></b>	<b>1.670g</b>
<b>S<sub>D1</sub></b>	<b>1.620g</b>
<b>S<sub>MS</sub></b>	<b>2.506g</b>
<b>S<sub>M1</sub></b>	<b>2.429g</b>
<b>T<sub>L</sub></b>	<b>8 Seconds</b>
<b>MCEG PGA</b>	<b>0.95g</b>
<b>Shear-Wave Velocity (V<sub>100</sub>)</b>	<b>1,075.1 ft/sec</b>
<b>Site Classification</b>	<b>D</b>
<b>Risk Category</b>	<b>IV</b>

**HISTORIC SEISMICITY**

A computerized search, based on Southern California historical earthquake catalogs, has been performed using the computer program EQSEARCH (Blake, 1989-2021) and the ANSS Comprehensive Earthquake Catalog (U.S.G.S., 2024a). The following table and discussion summarizes the historic seismic events (greater than or equal to M4.0) that have been estimated and/or recorded during the time period of 1800 to July 2024, within a 100-kilometer radius of the site.

TABLE 2 - HISTORIC SEISMIC EVENTS; 1800-2024 (100-kilometer radius)

<u>Richter Magnitude (M)</u>	<u>No. of Events</u>
4.0 - 4.9	628
5.0 - 5.9	73
6.0 - 6.9	15
7.0 - 7.9	1
8.0+	0

It should be noted that pre-instrumental seismic events (generally before 1932) have been estimated from isoseismal maps (Toppozada, et al., 1981 and 1982). These data have been compiled generally based on the reported intensities throughout the region, thus focusing in on the most likely epicentral location. Instrumentation beyond 1932 has greatly increased the accuracy of locating earthquake epicenters. A summary of the historic earthquake data is as follows:

- ❑ The closest recorded notable earthquake epicenter (magnitude 4.0 or greater) is a M4.2 event (June 28, 1997), which occurred approximately three miles to the west-northwest.
- ❑ The nearest estimated significant historic earthquake epicenter (pre-1932) was approximately 4± miles southwest of the site (July 15, 1905, M5.3).
- ❑ The nearest recorded significant historic earthquake epicenter was a M5.6 event of October 16, 1999, located approximately 15 miles northeast of the site.
- ❑ The largest estimated historical earthquake epicenter (pre-1932) within a 62-mile radius of the site is a M6.9 event of December 8, 1812 (25± miles northwest).
- ❑ The largest recorded historical earthquake was the M7.6 Landers's event, located approximately 49 miles to the east (June 28, 1992).
- ❑ The largest estimated ground acceleration estimated to have been experienced at the site was at least 0.215g which resulted from the M5.3 event of July 15, 1905, located approximately 4± miles to the southwest (Blake, 1989-2000b) based on the attenuation relationship of Boore et al. (1997).

An Earthquake Epicenter Map which includes magnitudes 4.0 and greater for a 100-kilometer (62-mile) radius (blue circle) from the site (central blue dot), has been included below as Figure 1. This map was prepared using the ANSS Comprehensive Earthquake Catalog (U.S.G.S, 2024a) of instrumentally recorded events from the period of 1932 to July 2024.

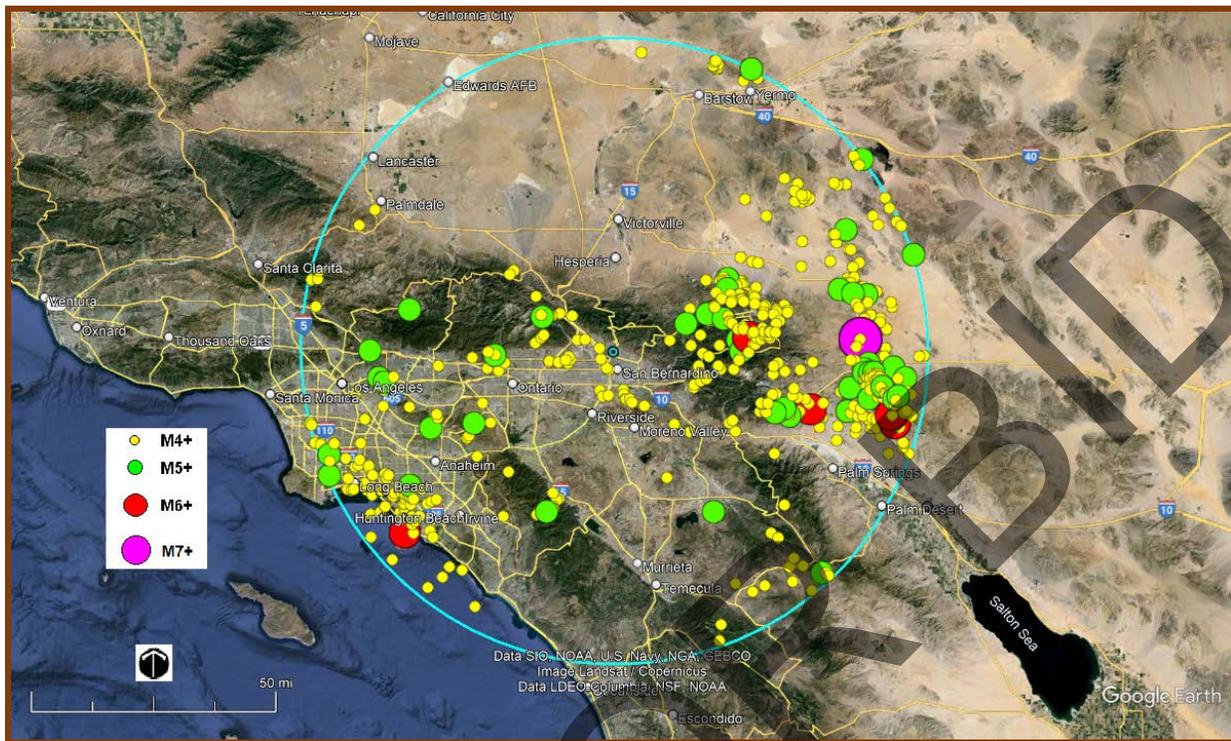


FIGURE 1- Earthquake Epicenter Map showing events of M4.0+ within a 100-kilometer radius.

## GROUNDWATER

The subject site is located within the Bunker Hill Basin, which is a subunit of the greater Upper Santa Ana Valley Groundwater Basin in Southern California. This basin is bordered on the west by the San Jacinto Fault, the northeast by the San Bernardino Mountains, the south by the Badlands, and east by Crafton Hills. The area of the basin is approximately 110 square miles. The water-bearing material in the basin consists of alluvial deposits of sand, gravel, and boulders interspersed with lenticular deposits of silt and clay. In the Bunker Hill Basin, most of the recharge to groundwater is supplied by runoff from the San Bernardino Mountains, and smaller amounts by deep penetration of rainfall and artificial recharge. Within the Bunker Hill Basin, groundwater generally flows similar to that of surface draining. Locally, groundwater flows toward the southwest (Duell and Schroeder, 1989).

Based on groundwater data provided by the California Department of Water Resources (2024b), the closest measured well was located 1,900± feet southeast of the site (State Well No. 01N04W22J001S), which indicates that groundwater had ranged from a depth of 124 to 154± feet between the time period of 1940 to 1944. Groundwater data prepared by Matti and Carson (1991) indicates that high groundwater was estimated to be around 150± feet in depth based on contour data. During the recent subsurface investigation performed by IFE (2024), groundwater was not encountered within any of the exploratory borings excavated at the site to a depth of at least 50½ feet.

## **SECONDARY SEISMIC HAZARDS**

Secondary permanent or transient seismic hazards that are generally associated with severe ground shaking during an earthquake include ground rupture, liquefaction, seiches or tsunamis, flooding (water storage facility failure), ground lurching/lateral spreading, landsliding, rockfalls, and seismically-induced settlement. These hazards are discussed below.

**Ground Rupture-** Ground rupture is generally considered most likely to occur along pre-existing faults. Since no known active faults are believed to traverse the subject site, the probability of ground rupture is considered very low to nil.

**Ground Lurching/Lateral Spreading-** Ground lurching is the horizontal movement of soil, sediments, or fill located on relatively steep embankments or scarps as a result of seismic activity, forming irregular ground surface cracks. The potential for lateral spreading or lurching is highest in areas underlain by soft, saturated materials, especially where bordered by steep banks or adjacent hard ground. Due to the flat-lying nature of the site, distance from embankments, the potential for ground lurching and/or lateral spreading is nil.

**Seismically-Induced Settlement-** Seismically-induced settlement generally occurs within areas of loose granular soils. The proposed construction area is locally underlain by interbedded fine- to medium-grained silty sand, fine- to coarse-grained sand with silt, fine- to coarse-grained sand, and gravel with fine- to coarse-grained sand, with gravel and cobbles throughout. Locally, portions of the upper 8± feet of the surface were noted to be in a loose condition, directly underlain by medium dense to very dense sediments, to a depth of at least 50½ feet. Therefore, there appears to be at least a low potential for seismically-induced settlement to occur.

**Landsliding-** Due to the relatively low-lying relief of the site, landsliding of the site due to seismic shaking is considered nil. According to the City of San Bernardino Slope Stability and Major Landslides Map (2005, Figure S-7), the site is not shown to be within the limits of generalized landslide susceptibility.

**Liquefaction-** In general, liquefaction is a phenomenon that occurs where there is a loss of strength or stiffness in the soils from repeated disturbances of saturated cohesionless soil that can result in the settlement of buildings, ground failures, or other such related hazards. The main factors generally contributing to this phenomenon are: 1) cohesionless, granular soils having relatively low densities (usually of Holocene age); 2) shallow groundwater (generally less than 40 feet); and 3) moderate-high seismic ground shaking. According to the City of San Bernardino Liquefaction Susceptibility Map (2005, Figure S-5), the subject site is not shown to be located within the limits of a liquefaction zone. Due to the greater than 50-foot depth to groundwater, dense nature of the alluvial deposits at depth, there does not appear to be a potential for liquefaction to occur.

**Flooding (Water Storage Facility Failure)**- Based on the data prepared by the California Department of Water Resources (2024a), the subject site is shown to be located within the limits of flood inundation in the event of catastrophic failure of the Little Mountain Dam, which is located approximately 2,700± feet to the northwest, as generally indicated on Figure 2 below (site outlined in red). Therefore, the potential for flooding due to water storage facility failure is considered possible. There are no other water-storage facilities that are topographically higher than that of the subject site, which could cause flooding due to catastrophic failure.

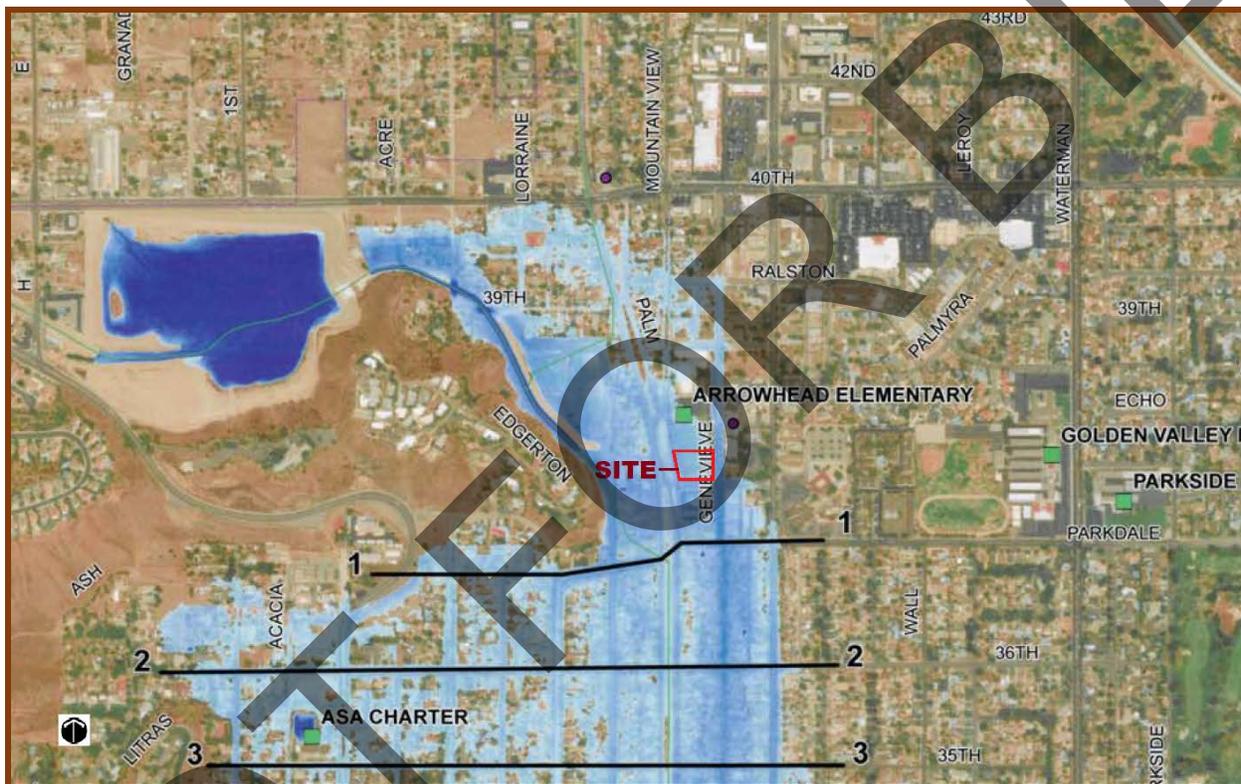


FIGURE 2- Dam Inundation Map (San Bernardino County, 2018); flooding shown as blue shading.

### **Seiches/Tsunamis-**

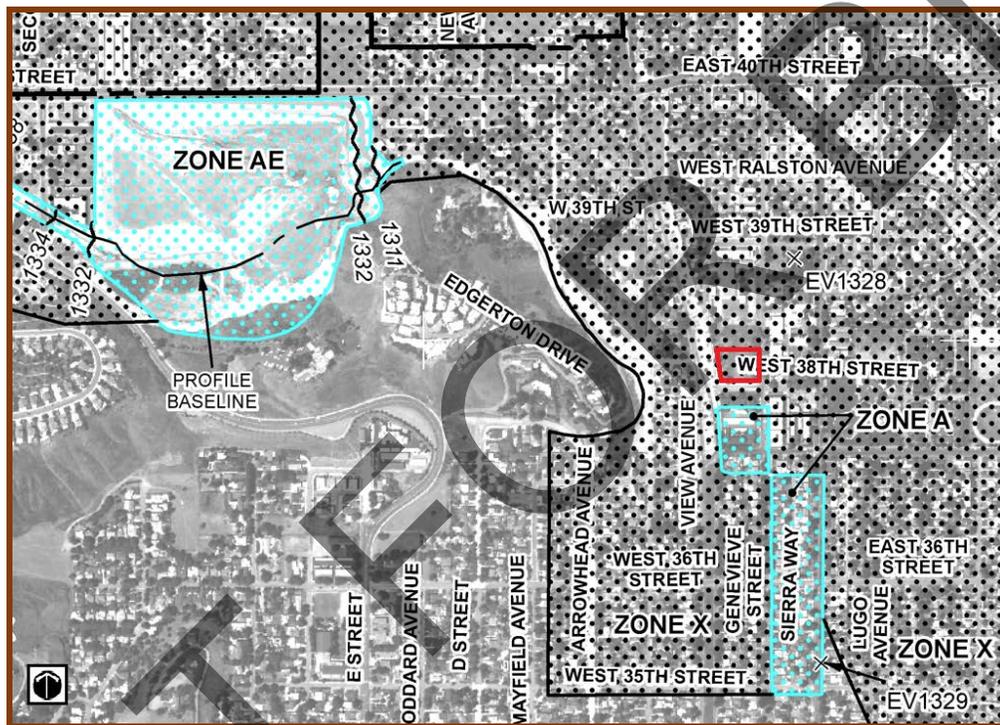
Based on the far distance of large, open bodies of water and the elevation of the site with respect to sea level, the possibility of seiches/tsunamis is considered nil. Additionally, mapping by the California Geological Survey (2014) does not indicate the site to be located within a tsunami inundation zone.

### **Rockfalls-**

The subject site lies upon a relatively flat-lying alluvial plain. Since no large rock outcrops are present at or adjacent to the site, the possibility of rockfalls during seismic shaking is nil.

## FLOODING

According to the Federal Emergency Management Agency (FEMA), the subject site is not located within the boundaries of a 100-year flood (Community Panel No. 06071C 7945H, September 26, 2008). The site is shown to be located within “Other Flood Areas - Zone X,” which is defined as “Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.” A portion of the FEMA Flood Zone Map is shown below in Figure 2 for reference.



**FIGURE 2- FEMA Flood Zone Map; Site boundary approximated by red outline.**

## GROUND SUBSIDENCE

Ground subsidence can be caused by natural geologic processes or by human activity such as groundwater and/or oil withdrawal and subsurface mining. Historic ground subsidence within the City of San Bernardino was generally located within the thick, poorly consolidated alluvial and marsh deposits of an old artesian area north of Loma Linda. Beginning in 1972, the San Bernardino Municipal Water District has maintained groundwater levels from recharge to percolation basins that, in turn, filter back into the alluvial deposits. Since the groundwater recharge program began, problems with ground subsidence in the valley have not been identified. According to the City of San Bernardino Potential Subsidence Areas Map (2005, Figure S-6), the subject site is not shown to be located within the limits of “Areas of Potential Ground Subsidence”.

## **OTHER GEOLOGIC HAZARDS**

There are other potential geologic hazards not necessarily associated with seismic activity that occur statewide. These hazards include; natural hazardous materials (such as methane gas, hydrogen-sulfide gas, and tar seeps); Radon-222 gas (EPA, 1993); naturally occurring asbestos; volcanic hazards (Martin, 1982); and regional subsidence. Of these hazards, there are none that appear to impact the site.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **General:**

Based on our review of available pertinent published and unpublished geologic/seismic literature, construction of the proposed new fire station facility appears to be feasible from a geologic standpoint, providing our recommendations are considered during planning and construction.

### **Conclusions:**

1. Based on available published geologic data, the subject site is underlain by both slightly- to moderately consolidated early Holocene and late Pleistocene alluvial fan deposits, generally described as sand and pebble-boulder gravel, along with late Holocene age very young wash deposits, consisting of unconsolidated to locally cemented sand, gravel, and boulder deposits. Site-specific exploration performed by IFE indicates the site to be underlain by interbedded fine- to medium-grained silty sand, fine- to coarse-grained sand with silt, fine- to coarse-grained sand, and gravel with fine- to coarse-grained sand, with gravel and cobbles throughout. Locally, portions of the upper 8± feet of the surface were noted to be in a loose condition, directly underlain by medium dense to very dense sediments, to a depth of at least 50½ feet.
2. Groundwater was not encountered within the exploratory excavations performed by IFE to a depth of at least 50½ feet. Nearby historic and current groundwater data indicate that groundwater may have been as high as 125± feet in depth, locally. No shallow groundwater conditions are anticipated to be encountered during construction.
3. Based on our literature research, there are no active faults that are known to traverse the subject site. The nearest zoned active fault is associated with the active San Andreas Fault (North Branch) located approximately 1.1± miles to the northeast.
4. The primary geologic hazard that exists at the site is that of ground shaking, which accounts for nearly all earthquake losses. Moderate to severe ground shaking could be anticipated during the life of the proposed development.

5. Due to the nature of the surficial underlying unconsolidated sediments, there may be a potential for secondary seismic settlement to occur. Additionally, the site lies within the inundation limits in the event of catastrophic failure of the Little Mountain Dam, located approximately 2,700± feet to the northwest. No other permanent and/or transient secondary seismic hazards are expected to occur within the proposed construction area.

### **Recommendations:**

1. The potential for seismically-induced settlement should be properly evaluated by the project Geotechnical Engineer. Appropriate site-specific mitigation measures, should be implemented as recommended, if warranted.
2. The potential for flooding due to catastrophic failure of Little Mountain Dam should be properly evaluated by the project Civil Engineer or other appropriate design professional. Appropriate site-specific mitigation measures, should be implemented as recommended, if warranted.
3. It is recommended that all structures be designed to at least meet the current California Building Code provisions in the latest 2022 CBC edition and the 2016 ASCE Standard 7-16, where applicable. However, it should be noted that the building code is intended as a minimum construction design and is often the maximum level to which structures are designed. Structures that are built to minimum code are designed to at least remain operational after an earthquake. It is the responsibility of both the property owner and project structural engineer to determine the risk factors with respect to using CBC minimum design values for the proposed facilities. When considering that a cascading rupture event could occur along the entire length of the San Andreas Fault Zone (which includes all segments), the resulting maximum moment magnitude earthquake is estimated to be Mw8.1, which should be used for seismic design purposes.

### **CLOSURE**

Our conclusions and recommendations are based on a review of available existing published geologic/seismic data and the provided site-specific subsurface exploratory boring logs. No subsurface exploration was performed by this firm for this evaluation. We make no warranty, either express or implied. Should conditions be encountered at a later date or more information becomes available that appear to be different than those indicated in this report, we reserve the right to reevaluate our conclusions and recommendations and provide appropriate mitigation measures, if warranted. It is assumed that all the conclusions and recommendations outlined in this report are understood and followed.

If any portion of this report is not understood, it is the responsibility of the owner, contractor, engineer, and/or governmental agency, etc., to contact this office for further clarification.

Respectfully submitted,  
**TERRA GEOSCIENCES**

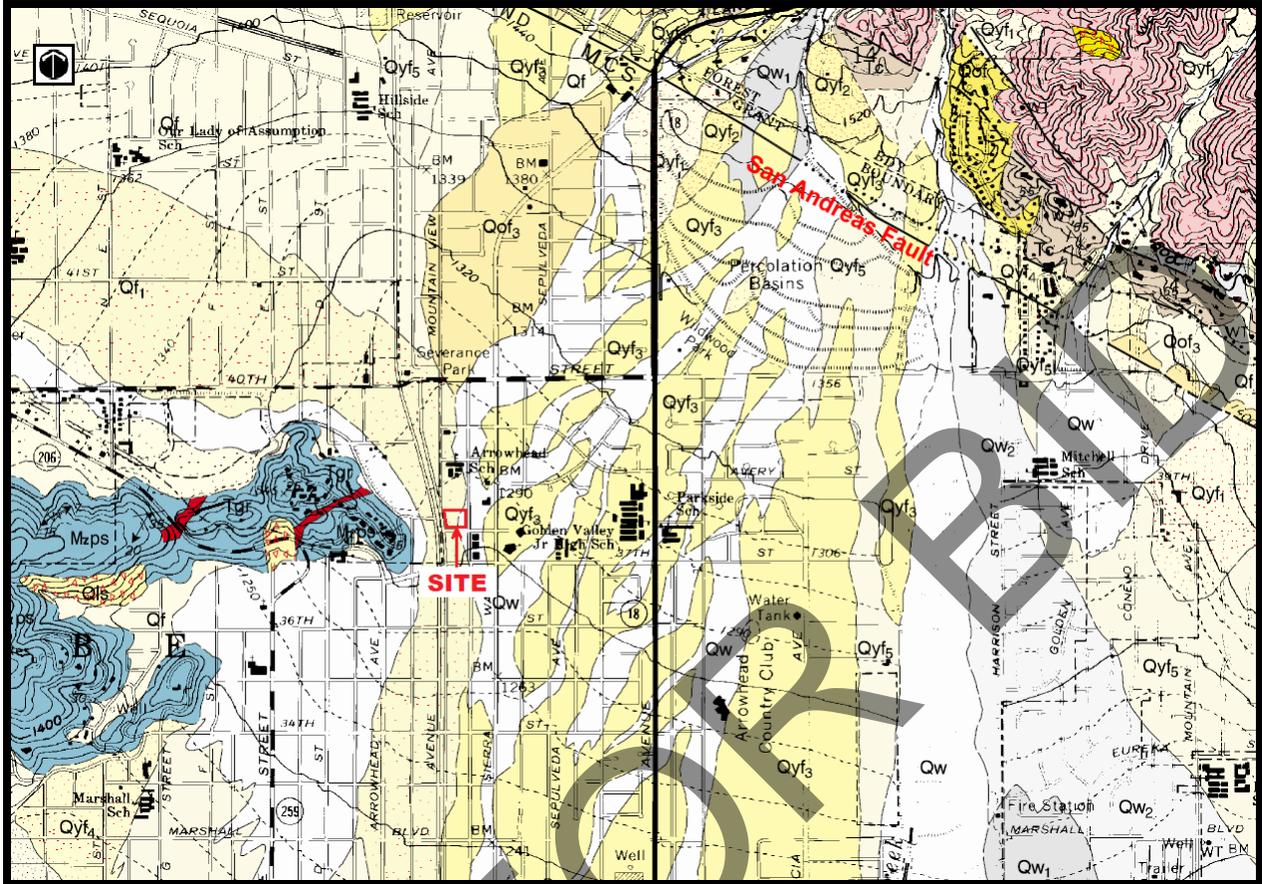


**Donn C. Schwartzkopf**  
Principal Geologist / Geophysicist  
CEG 1459 / PGP 1002



NOT FOR

# REGIONAL GEOLOGIC MAP

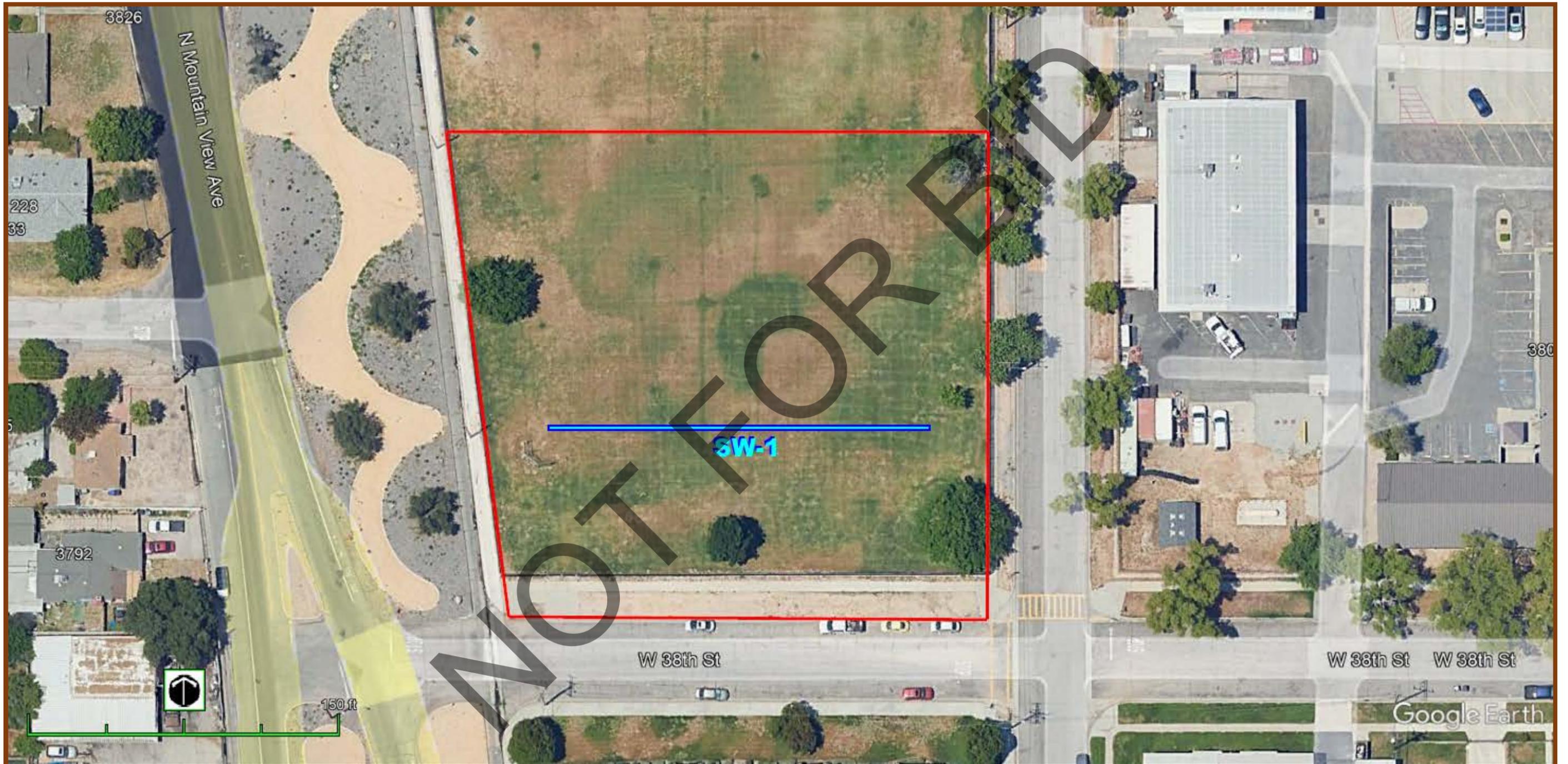


BASE MAP: Miller et al. (2001), U.S.G.S., Open File Report 01-131, Scale 1: 24,000, Site outlined in red.

## PARTIAL LEGEND

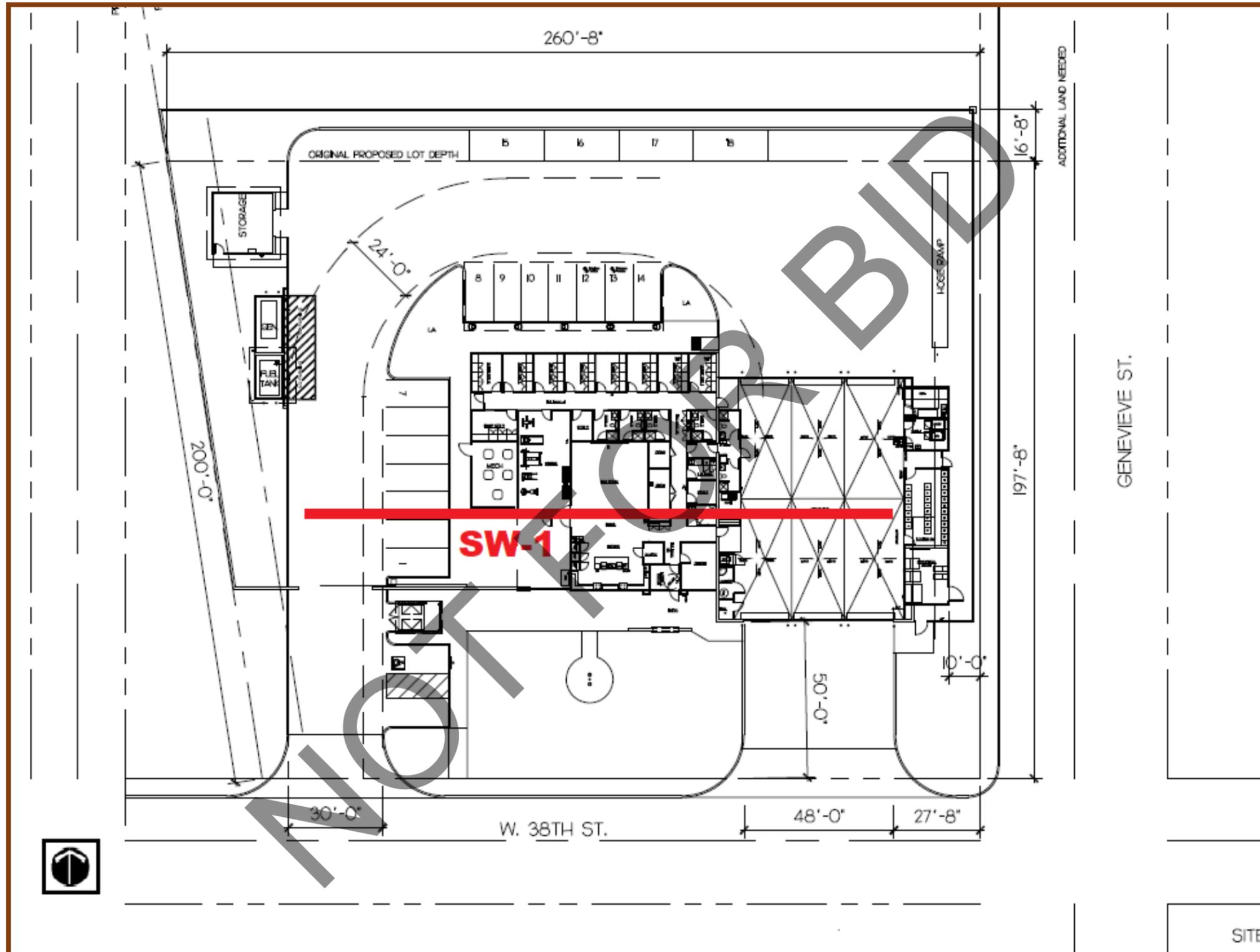
- |   |                                   |   |
|---|-----------------------------------|---|
| <div style="border: 1px solid black; padding: 2px; width: 40px; text-align: center; margin-bottom: 10px;">Qw</div>              | <p><b>YOUNG WASH DEPOSITS</b></p> | <p>Unconsolidated to locally cemented sand, gravel and boulders (late Holocene).</p>                              |
| <div style="border: 1px solid black; padding: 2px; width: 40px; text-align: center; margin-bottom: 10px;">Qyf<sub>1</sub></div> | <p><b>YOUNG FAN DEPOSITS</b></p>  | <p>Slightly- to moderately-consolidated sand and pebble-boulder gravel (early Holocene and late Pleistocene).</p> |
| <div style="border: 1px solid black; padding: 2px; width: 40px; text-align: center; margin-bottom: 10px;">Mzps</div>            | <p><b>PELONA SCHIST</b></p>       | <p>Muscovite-chlorite-albite-quartz schist, fine-grained (Mesozoic).</p>  |
| <p>— — — — —</p>  | <p><b>GEOLOGIC CONTACT</b></p>    | <p>Solid where located within 15± meters; dashed where located within 30± meters.</p>                             |
| <p>— — — — —</p>  | <p><b>FAULT</b></p>               | <p>Solid where located within 15± meters; dashed where located within 30± meters; dotted where concealed.</p>     |

# GOOGLE™ EARTH IMAGERY MAP



Base Map: Captured Google™ Earth (2024); Seismic shear-wave traverse **SW-1** shown as blue line, approximate site boundary outlined in red.

# SITE PLAN



BASE MAP: Provided "FS 227 Conceptual Site Plan" (Sheet A0.1, dated 6/12/24); prepared by STK Architecture, Inc., Temecula, California.

# **APPENDIX A**

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## **SHEAR-WAVE SURVEY**

NOT FOR BID



# SHEAR-WAVE SURVEY

## Methodology

The fundamental premise of this survey uses the fact that the Earth is always in motion at various seismic frequencies. These relatively constant vibrations of the Earth's surface are called microtremors, which are very small with respect to amplitude and are generally referred to as background "noise" that contain abundant surface waves. These microtremors are caused by both human activity (i.e., cultural noise, traffic, factories, etc.) and natural phenomenon (i.e., wind, wave motion, rain, atmospheric pressure, etc.) which have now become regarded as useful signal information. Although these signals are generally very weak, the recording, amplification, and processing of these surface waves has greatly improved by the use of technologically improved seismic recording instrumentation and recently developed computer software. For this application, we are mainly concerned with the Rayleigh wave portion of the seismic signals, which is also referred to as "ground roll" since the Rayleigh wave is the dominant component of ground roll.

For the purposes of this study, there are two ways that the surface waves were recorded, one being "active" and the other being "passive." Active means that seismic energy is intentionally generated at a specific location relative to the survey spread and recording begins when the source energy is imparted into the ground (i.e., MASW survey technique). Passive surveying, also called "microtremor surveying," is where the seismograph records ambient background vibrations (i.e., MAM survey technique), with the ideal vibration sources being at a constant level. Longer wavelength surface waves (longer-period and lower-frequency) travel deeper and thus contain more information about deeper velocity structure and are generally obtained with passive survey information. Shorter wavelength (shorter-period and higher-frequency) surface waves travel shallower and thus contain more information about shallower velocity structure and are generally collected with the use of active sources.

For the most part, higher frequency active source surface waves will resolve the shallower velocity structure and lower frequency passive source surface waves will better resolve the deeper velocity structure. Therefore, the combination of both of these surveying techniques provides a more accurate depiction of the subsurface velocity structure.

The assemblage of the data that is gathered from these surface wave surveys results in development of a dispersion curve. Dispersion, or the change in phase velocity of the seismic waves with frequency, is the fundamental property utilized in the analysis of surface wave methods. The fundamental assumption of these survey methods is that the signal wavefront is planar, stable, and isotropic (coming from all directions) making it independent of source locations and for analytical purposes uses the spatial autocorrelation method (SPAC). The SPAC method is based on theories that are able to detect "signals" from background "noise" (Okada, 2003). The shear wave velocity ( $V_s$ ) can then be calculated by mathematical inversion of the dispersive phase velocity of the surface waves which can be significant in the presence of velocity layering, which is common in the near-surface environment.

## **Field Procedures**

One shear-wave survey traverse (SW-1) was performed within proposed construction area, as approximated on Plates 1 and 2. For data collection, the field survey employed a twenty-four channel Geometrics StrataVisor™ NZXP model signal-enhancement refraction seismograph. This survey employed both active source (MASW) and passive (MAM) methods to ensure that both quality shallow and deeper shear-wave velocity information was recorded (Park et al., 2005).

Both the MASW and MAM survey lines used the same linear geometry array that consisted of a 184-foot-long spread using a series of twenty-four 4.5-Hz geophones that were spaced at regular eight-foot intervals. For the active source MASW survey, the ground vibrations were recorded using a one second record length at a sampling rate of 0.5-milliseconds. Two separate seismic records were obtained using a 30-foot shot offset at both ends of the line utilizing a 16-pound sledge-hammer as the energy source to produce the seismic waves. Numerous seismic impacts were used at each shot location to improve the signal-to-noise ratio.

The MAM survey did not require the introduction of any artificial seismic sources with only background ambient noise (i.e., air and vehicle traffic, etc.) being necessary. These ambient ground vibrations were recorded using a thirty-two second record length at a two-millisecond sampling rate with 21 separate seismic records being obtained for quality control purposes. The frequency spectrum data that was displayed on the seismograph screen were used to assess the recorded seismic wave data for quality control purposes in the field. The acceptable records were digitally recorded on the in-board seismograph computer and subsequently transferred to a flash drive so that they could be subsequently transferred to our office computer for analysis.

## **Data Reduction**

For analysis and presentation of the shear-wave profile and supportive illustration, this study used the **SeisImager/SW™** computer software program that was developed by Geometrics, Inc. (2021). Both the active (MASW) and passive (MAM) survey results were combined for this analysis (Park et al., 2005). The combined results maximize the resolution and overall depth range in order to obtain one high resolution  $V_s$  curve over the entire sampled depth range. These methods economically and efficiently estimate one-dimensional subsurface shear-wave velocities using data collected from standard primary-wave (P-wave) refraction surveys.

However, it should be noted that surface waves by their physical nature cannot resolve relatively abrupt or small-scale velocity anomalies and this model should be considered as an approximation. Processing of the data then proceeded by calculating the dispersion curve from the input data from both the active and passive data records, which were subsequently combined creating an initial shear-wave ( $V_s$ ) model based on the observed data. This initial model was then inverted in order to converge on the best fit of the initial model and the observed data, creating the final  $V_s$  curve as presented within this appendix.

## Summary of Data Analysis

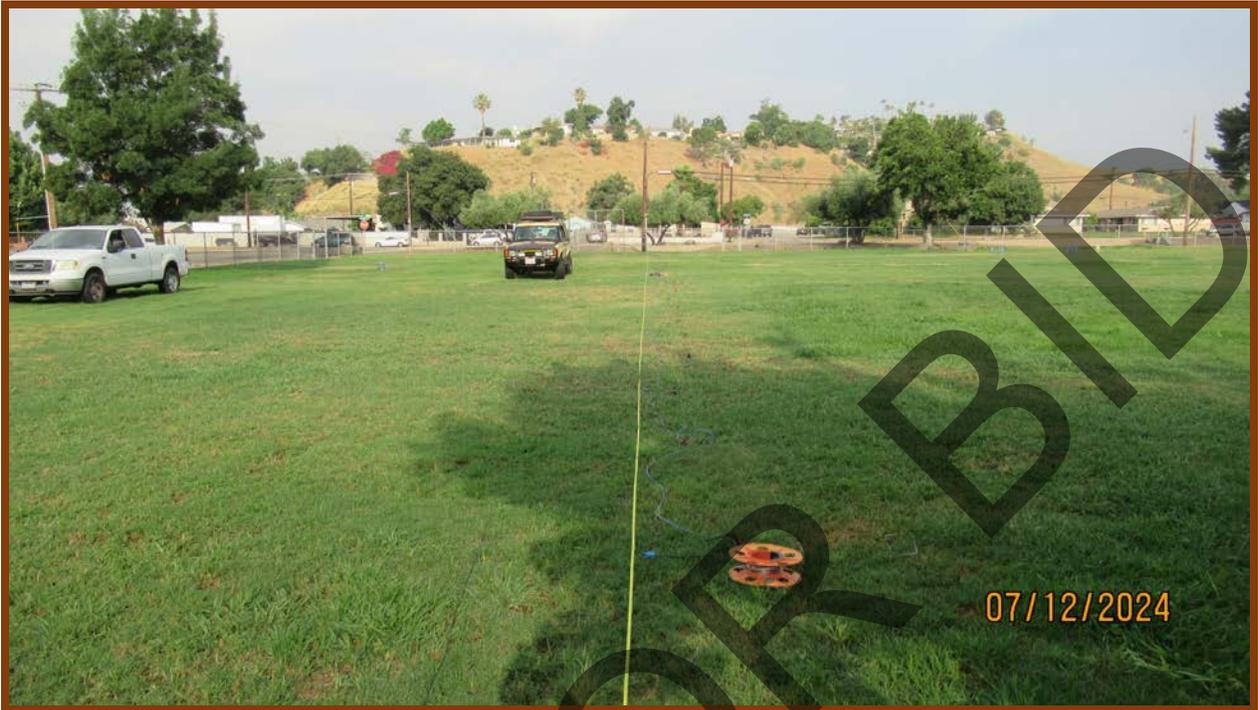
Data acquisition went very smoothly and the quality was considered to be good. Analysis revealed that the average shear-wave velocity (“weighted average”) in the upper 100 feet of the subject survey area is **1,075.1** feet per second (327.7 meters/second) as shown on the shear-wave model for Seismic Line SW-1, as presented within this appendix. This average velocity classifies the underlying soils to that of Site Class “**D**” (“Stiff Soil” profile), which has a velocity range from 600 to 1,200 ft/sec (ASCE, 2017; Table 20.3-1).

The “weighted average” velocity is computed from a formula that is used by the ASCE (2017; Section 20.4, Equation 20.4-1) to determine the average shear-wave velocity for the upper 100 feet of the subsurface (V100).

$$V_s = 100/[(d_1/v_1) + (d_2/v_2) + \dots + (d_n/v_n)]$$

Where  $d_1, d_2, d_3, \dots, d_n$ , are the thicknesses for layers 1, 2, 3, ...,  $n$ , up to 100 feet, and  $v_1, v_2, v_3, \dots, v_n$ , are the seismic velocities (feet/second) for layers 1, 2, 3, ...,  $n$ . The detailed shear-wave model displays these calculated layer boundaries/depths and associated velocities (feet/second) for the 200-foot profile where locally measured. The constrained data is represented by the dark-gray shading on the shear-wave model. The associated Dispersion Curves (for both the active and passive methods) which show the data quality and picks, along with the resultant combined dispersion curve model, are also included within this appendix, for reference purposes.

# SURVEY LINE PHOTOGRAPHS

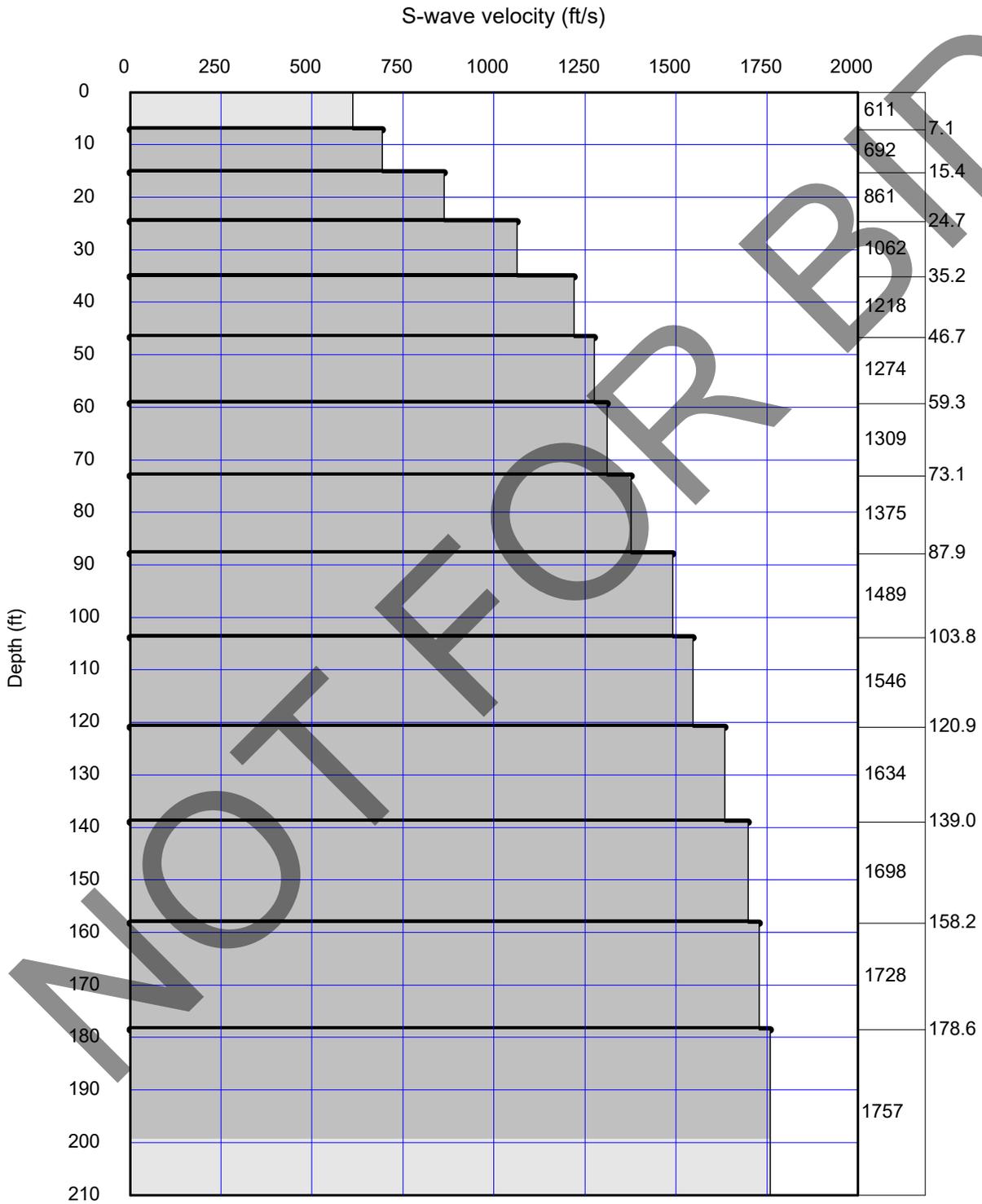


View looking west along Seismic Line SW-1.



View looking east along Seismic Line SW-1.

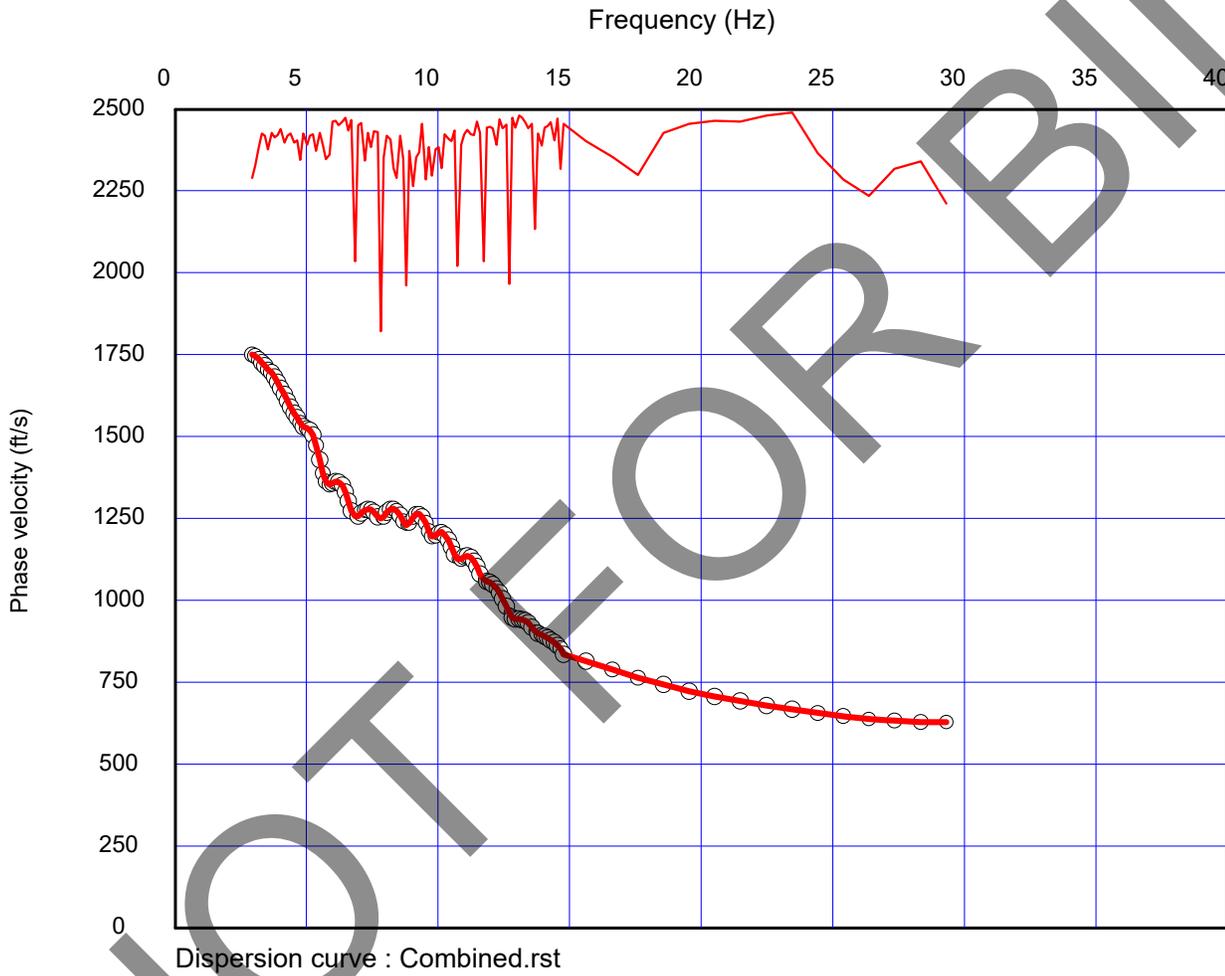
# SEISMIC LINE SW-1 SHEAR-WAVE MODEL



S-wave velocity model (inverted): Final.rst

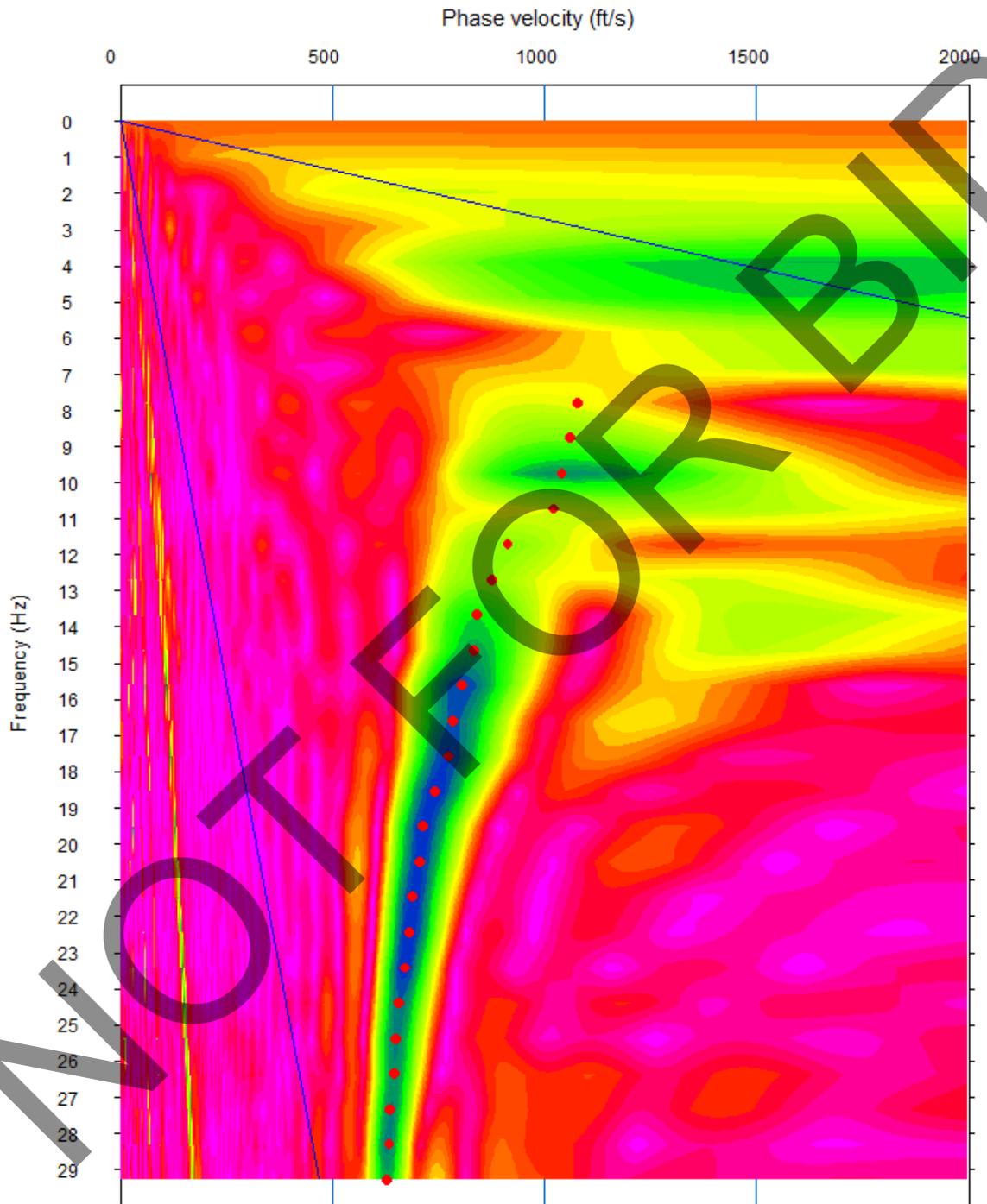
Average Vs 100ft = 1075.1 ft/sec

# SEISMIC LINE SW-1



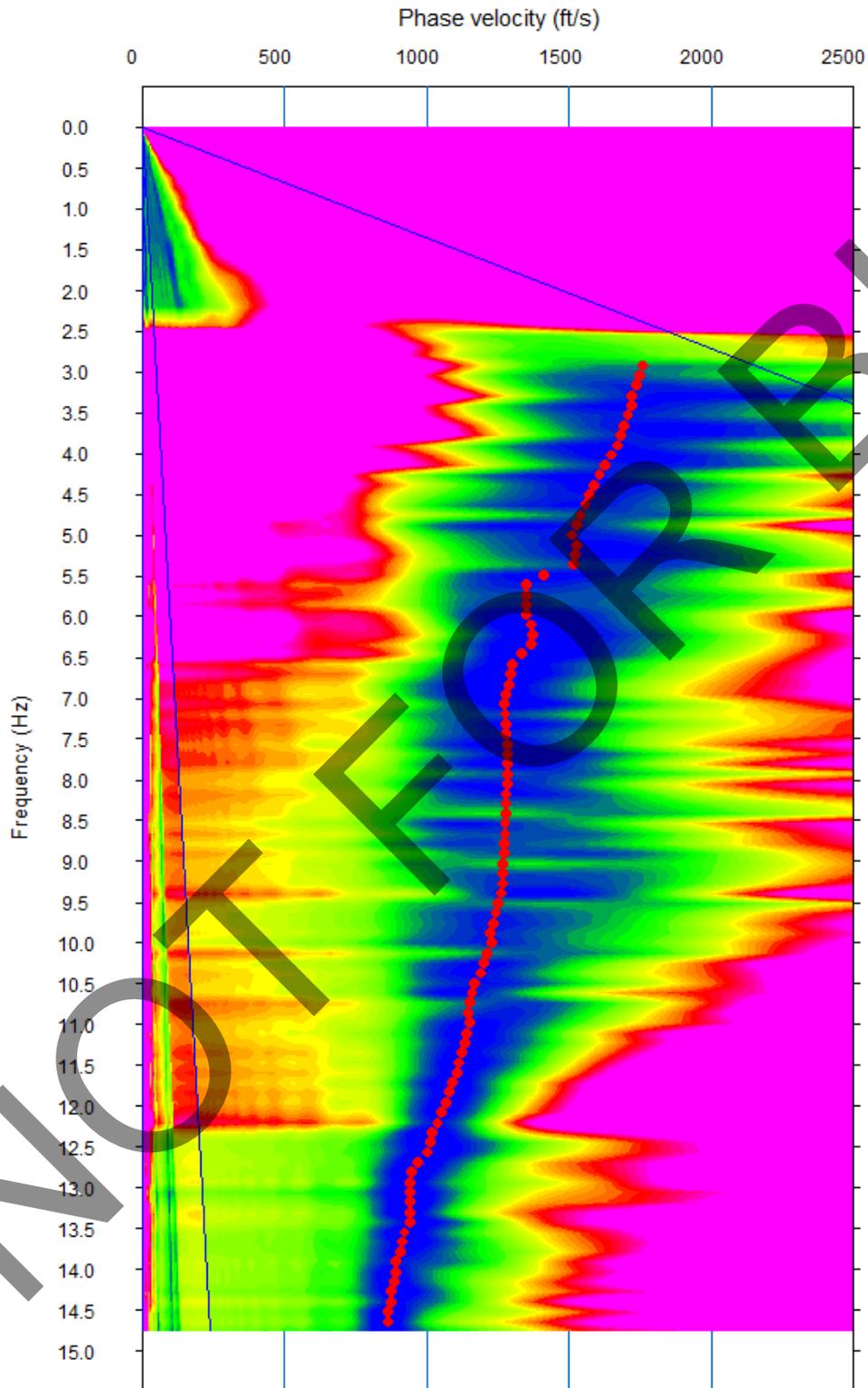
## COMBINED DISPERSION CURVE

# SEISMIC LINE SW-1



## ACTIVE DISPERSION CURVE

# SEISMIC LINE SW-1



Dispersion Curve: Passive.dat

## PASSIVE DISPERSION CURVE

# APPENDIX B

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## SITE-SPECIFIC GROUND MOTION ANALYSIS

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# SITE-SPECIFIC GROUND MOTION ANALYSIS

A detailed summary of the site-specific ground motion analysis, which follows Section 21 of the ASCE Standard 7-16 (2017) and the 2022 California Building Code is presented below, with the Seismic Design Parameters Summary included within this appendix following the summary text.

## ◆ Mapped Spectral Acceleration Parameters (CBC 1613A.2.1)-

Based on maps prepared by the U.S.G.S (Risk-Adjusted Maximum Considered Earthquake ( $MCE_R$ ) Ground Motion Parameter for the Conterminous United States for the 0.2 and 1-second Spectral Response Acceleration (5% of Critical Damping; Site Class B/C), a value of **2.506g** for the 0.2 second period ( $S_s$ ) and **1.002g** for the 1.0 second period ( $S_1$ ) was calculated (ASCE 7-16 Figures 22-1, 22-2 and CBC 1613A.2.1).

## ◆ Site Classification (CBC 1613A.2.2 & ASCE 7-16 Chapter 20)-

Based on the site-specific measured shear-wave value of 1,075.1 feet/second (327.7 meters/second), the soil profile type used should be Site Class “D.” This Class is defined as having the upper 100 feet (30 meters) of the subsurface being underlain by “stiff soil” with average shear-wave velocities of 600 to 1,200 feet/second (180 to 360 meters/second), as detailed within Appendix A.

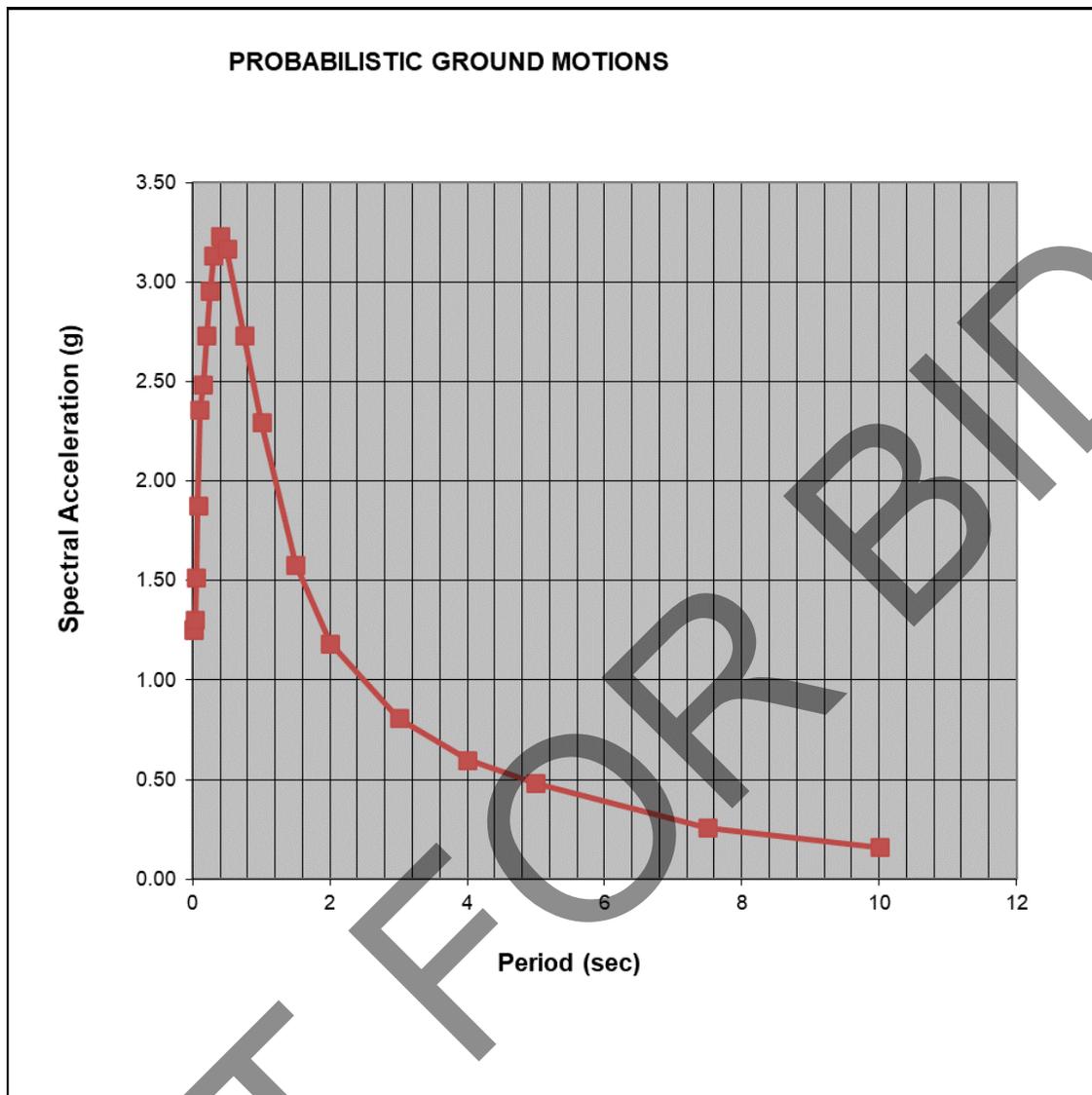
## ◆ Site Coefficients (CBC 1613A.2.3)-

Based on CBC Tables 1613A.2.3(1) and 1613A.2.3(2), the site coefficient  $F_a = 1.2$  and  $F_v = 1.7$ , respectively.

## ◆ Probabilistic ( $MCE_R$ ) Ground Motions (ASCE 7 Section 21.2.1)-

Per Section 21.2.1, the probabilistic MCE spectral accelerations shall be taken as the spectral response accelerations in the direction of maximum response represented by a five percent damped acceleration response spectrum that is expected to achieve a one percent probability of collapse within a 50-year period.

The probabilistic analysis included the use of the Open Seismic Hazard Analysis (OpenSHA). The selected Earthquake Rupture Forecast (ERF) was UCERF3 along with a Probability of Exceedance of 2% in 50 Years. The average of four Next Generation Attenuation West-2 Relations (2014 NGA) were utilized to produce a response spectrum. These included Chiou & Youngs (2014), Abrahamsom et al. (2014), Campbell & Bozorgnia (2014), Boore et al. (2014), and Campbell & Bozorgnia (2014). The Probabilistic Risk Targeted Response Spectrum was determined as the product of the ordinates of the probabilistic response spectrum and the applicable risk coefficient ( $C_R$ ). These values were then modified to produce a spectrum based upon the maximum rotated components of ground motion. The resulting  $MCE_R$  Response Spectrum is indicated below:



◆ **Deterministic Spectral Response Analyses (ASCE 7 Section 21.2.2)-**

The deterministic  $MCE_R$  response acceleration at each period shall be calculated as an 84<sup>th</sup>-percentile 5 percent damped spectral response acceleration in the direction of maximum horizontal response computed at that period. The largest such acceleration calculated for the characteristic earthquakes on all known active faults within the region shall be used. Analyses were conducted using the average of four Next Generation Attenuation West-2 Relations (2014 NGA), including Chiou & Youngs (2014), Abrahamsom et al. (2014), Boore et al. (2014) and Campbell & Bozorgnia (2014).

Based on our review of the Fault Section Database within the Uniform California Earthquake Rupture Forecast (UCERF 3; Field et al., 2013), published geologic data, and based on the length (combined segments) and maximum magnitude of the San Andreas Fault Zone (southern section) located 1.8 kilometers to the northeast, a moment magnitude ( $M_w$ ) used for this fault was 8.1.

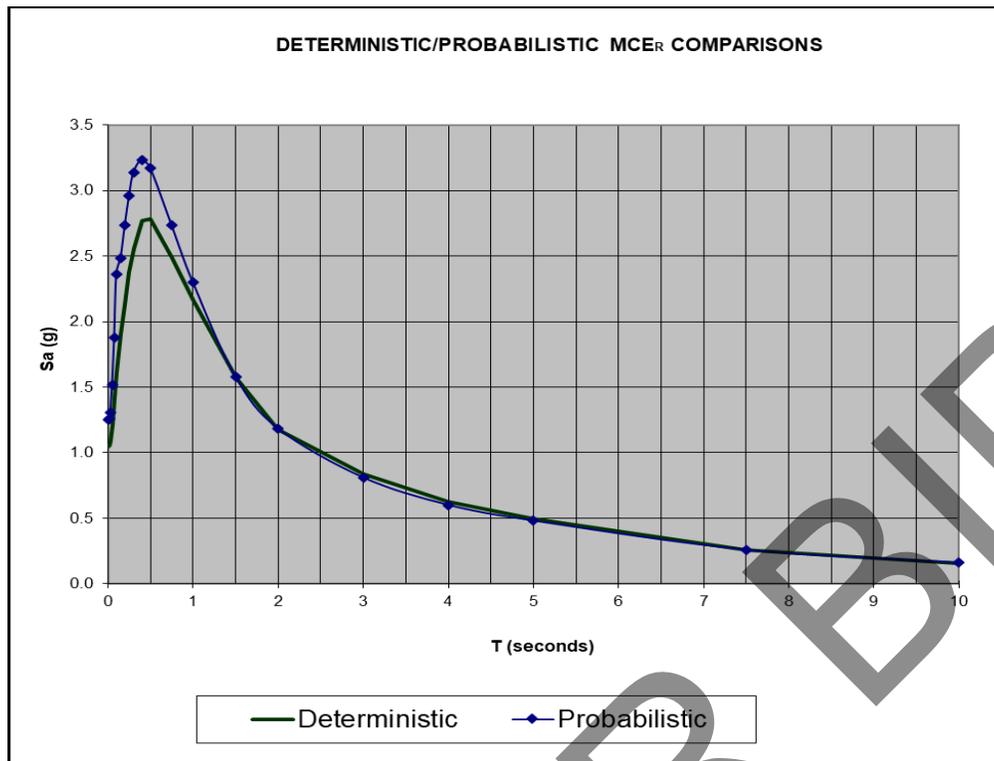
◆ **Site Specific  $MCE_R$  (ASCE 7 Section 21.2.3)-**

The site-specific  $MCE_R$  spectral response acceleration at any period,  $S_{aM}$ , shall be taken as the lesser of the spectral response accelerations from the probabilistic ground motions of Section 21.2.1 and the deterministic ground motions of Section 21.2.2. The deterministic ground motions were compared with the probabilistic ground motions that were determined in accordance with Section 21.2.1.

**Comparison of Deterministic  $MCE_R$  Values with Probabilistic  $MCE_R$  Values - Section 21.2.3**

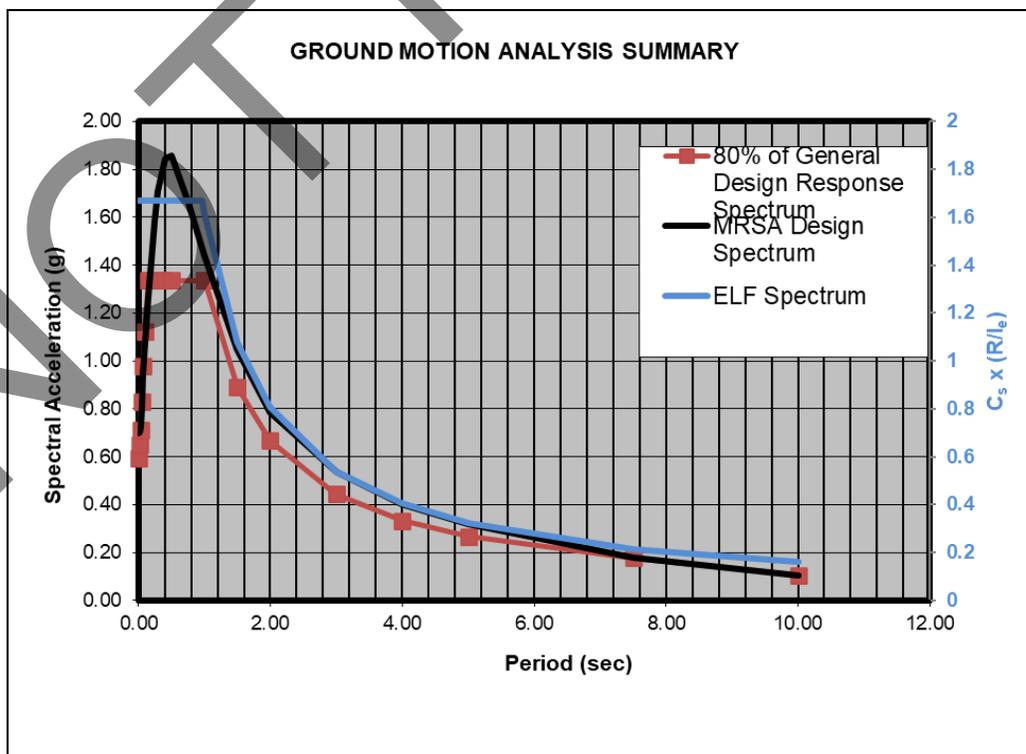
Period	Deterministic	Probabilistic	Lower Value (Site Specific $MCE_R$ )	Governing Method
T	$MCE_R$	$MCE_R$	$MCE_R$	
0.010	1.05	1.25	1.05	Deterministic Governs
0.020	1.06	1.26	1.06	Deterministic Governs
0.030	1.09	1.31	1.09	Deterministic Governs
0.050	1.21	1.52	1.21	Deterministic Governs
0.075	1.42	1.88	1.42	Deterministic Governs
0.100	1.61	2.36	1.61	Deterministic Governs
0.150	1.90	2.49	1.90	Deterministic Governs
0.200	2.13	2.73	2.13	Deterministic Governs
0.250	2.37	2.96	2.37	Deterministic Governs
0.300	2.56	3.13	2.56	Deterministic Governs
0.400	2.77	3.23	2.77	Deterministic Governs
0.500	2.78	3.17	2.78	Deterministic Governs
0.750	2.49	2.73	2.49	Deterministic Governs
1.000	2.16	2.30	2.16	Deterministic Governs
1.500	1.57	1.58	1.57	Deterministic Governs
2.000	1.18	1.18	1.18	Deterministic Governs
3.000	0.84	0.81	0.81	Probabilistic Governs
4.000	0.63	0.60	0.60	Probabilistic Governs
5.000	0.49	0.48	0.48	Probabilistic Governs
7.500	0.26	0.26	0.26	Deterministic Governs
10.000	0.15	0.16	0.15	Deterministic Governs

These are plotted in the following diagram:



◆ **Design Response Spectrum (ASCE 7 Section 21.3)-**

In accordance with Section 21.3, the Design Response Spectrum was developed by the following equation:  $S_a = 2/3S_{aM}$ , where  $S_{aM}$  is the MCE<sub>R</sub> spectral response acceleration obtained from Section 21.1 or 21.2. The design spectral response acceleration shall not be taken less than 80 percent of  $S_a$ . These are plotted and compared with 80% of the CBC Spectrum values in the following diagram:



◆ **Design Acceleration Parameters (ASCE 7 Section 21.4)-**

Where the site-specific procedure is used to determine the design ground motion in accordance with Section 21.3, the parameter  $S_{DS}$  shall be obtained from the site-specific spectra at a period of 0.2 s, except that it shall not be taken less than 90 percent of the peak spectral acceleration,  $S_a$ , at any period larger than 0.2 s. The parameter  $S_{D1}$  shall be taken as the greater of the products of  $S_a * T$  for periods between 1 and 5 seconds. The parameters  $S_{MS}$ , and  $S_{M1}$  shall be taken as 1.5 times  $S_{DS}$  and  $S_{D1}$ , respectively. The values so obtained shall not be less than 80 percent of the values determined in accordance with Section 11.4.4 for  $S_{MS}$ , and  $S_{M1}$  and Section 11.4.5 for  $S_{DS}$  and  $S_{D1}$ .

◆ **Site Specific Design Parameters -**

For the 0.2 second period ( $S_{DS}$ ), the maximum average acceleration for any period exceeding 0.2 seconds was 1.86g occurring at  $T=0.50$  seconds. This was multiplied by 0.9 to produce a value of 1.67g making this the applicable value. A value of 1.62g was calculated for  $S_{D1}$  at a period of 1 second (ASCE 7-16, 21.4). For the  $MCE_R$  0.2 second period, a value of 2.506g ( $S_{MS}$ ) was computed, along with a value of 2.429g ( $S_{M1}$ ) for the  $MCE_R$  1.0 second period was also calculated (ASCE 7-16, 21.2.3).

◆ **Site-Specific  $MCE_G$  Peak Ground Accelerations (ASCE 7 Section 21.5)-**

The probabilistic geometric mean peak ground acceleration (2 percent probability of exceedance within a 50-year period) was calculated as 1.24g. The deterministic geometric mean peak ground acceleration (largest 84<sup>th</sup> percentile geometric mean peak ground acceleration for characteristic earthquakes on all known active faults within the site region) was calculated as 0.95g. The site-specific  $MCE_G$  peak ground acceleration was calculated to be **0.95g**, which was determined by using the lesser of the probabilistic (1.24g) or the deterministic (0.95g) geometric mean peak ground accelerations, but not taken as less than 80 percent of  $PGA_M$  (i.e.,  $1.14g \times 0.80 = 0.92g$ ).

# SEISMIC DESIGN PARAMETERS SUMMARY

Project: San Bernardino County Fire Station #227 Latitude: 34.1601  
 Project #: 244073-1 Longitude: -117.2866  
 Date: 7/14/2024

## CALIFORNIA BUILDING CODE CHAPTER 16/ASCE7-16

### Mapped Acceleration Parameters per ASCE 7-16, Chapter 22

$S_s$	= 2.506	Figure 22-1
$S_1$	= 1.002	Figure 22-2

### Site Class per Table 20.3-1

Site Class = D - Stiff Soil

### Site Coefficients per ASCE 7-16 CHAPTER 11

$F_a$	= 1	Table 11.4-1	=	1	For Site Specific Analysis per ASCE7-16 21.3
$F_v$	= 1.7	Table 11.4-2	=	2.50	For Site Specific Analysis per ASCE7-16 21.3

### Mapped Design Spectral Response Acceleration Parameters

$S_{Ms}$	= 2.506	Equation 11.4-1	=	2.506	For Site Specific Analysis per ASCE7-16 21.3
$S_{M1}$	= 1.703	Equation 11.4-2	=	2.505	For Site Specific Analysis per ASCE7-16 21.3

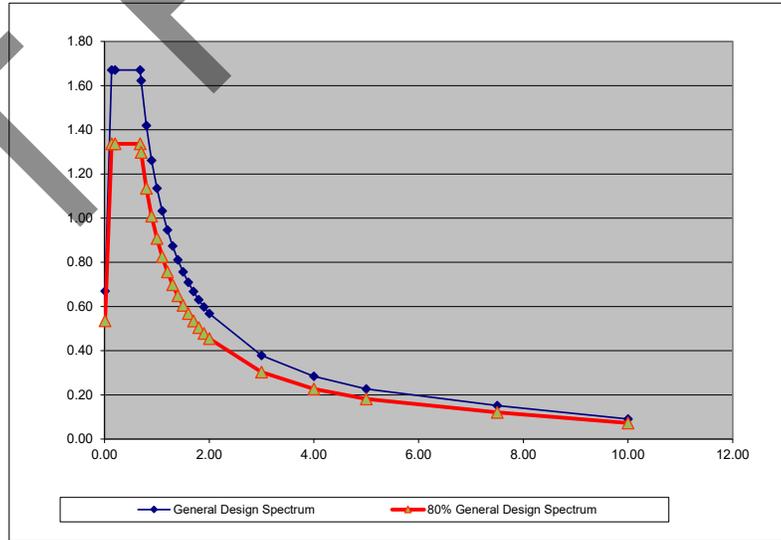
$S_{DS}$	= 1.671	Equation 11.4-3
$S_{D1}$	= 1.136	Equation 11.4-4

Period (T)	$S_a$ (ASCE7-16 11.4.6)	80% General Design Spectrum
0.01	0.67	0.54
0.14	1.67	1.34
0.20	1.67	1.34
0.68	1.67	1.34
0.70	1.62	1.30
0.80	1.42	1.14
0.90	1.26	1.01
1.00	1.14	0.91
1.10	1.03	0.83
1.20	0.95	0.76
1.30	0.87	0.70
1.40	0.81	0.65
1.50	0.76	0.61
1.60	0.71	0.57
1.70	0.67	0.53
1.80	0.63	0.50
1.90	0.60	0.48
2.00	0.57	0.45
3.00	0.38	0.30
4.00	0.28	0.23
5.00	0.23	0.18
7.50	0.15	0.12
10.00	0.09	0.07

$T_0$	= 0.136	sec
$T_S$	= 0.680	sec
$T_L$	= 8	sec
PGA	= 1.04	g
$F_{PGA}$	= 1.1	
$C_{RS}$	= 0.905	
$C_{R1}$	= 0.884	

From Fig 22-12

From Table 11.8-1  
 Figure 22-17  
 Figure 22-18



**ASCE 7-16 - RISK-TARGETED MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION ANALYSIS**

Use Maximum Rotated Horizontal Component?\* (Y/N) Y

Presented data are the average of Chiou & Youngs (2014), Abrahamson et. al. (2014), Boore et. al (2014) and Campbell & Bozorgnia (2014) NGA West-2 Relat Earthquake Rupture Forecast - UCERF3 Mean, FM 3.1 & 3.2

**PROBABILISTIC MCER per 21.2.1.1 Method 1**

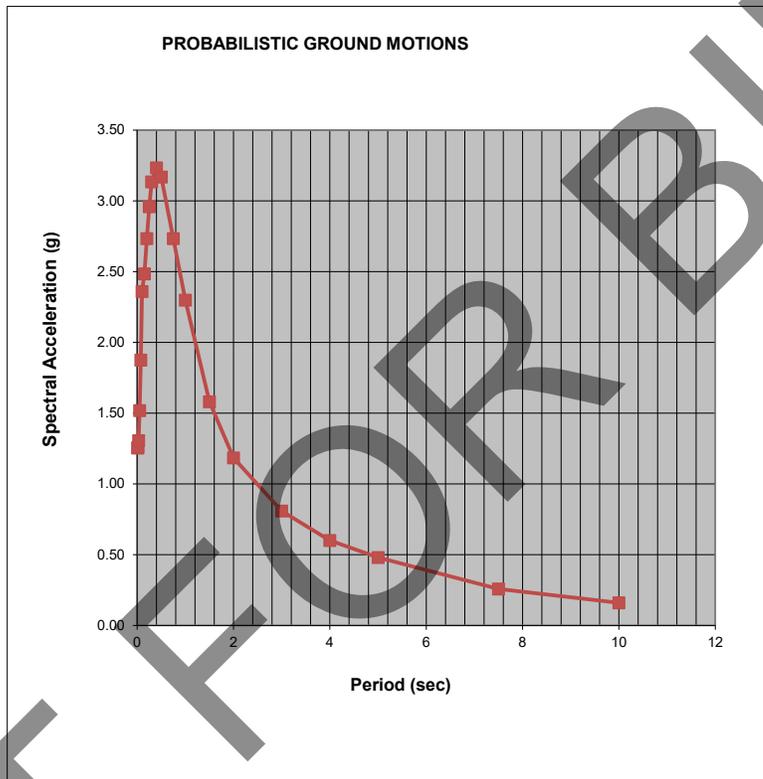
Risk Coefficients taken from Figures 22-18 and 22-19 of ASCE 7-16

OpenSHA data

2% Probability Of Exceedance in 50 years

Maximum Rotated Horizontal Component determined per ASCE7-16

T	Sa 2% in 50	MCER
0.01	1.39	1.25
0.02	1.39	1.26
0.03	1.44	1.31
0.05	1.68	1.52
0.08	2.07	1.88
0.10	2.37	2.36
0.15	2.75	2.49
0.20	3.02	2.73
0.25	3.27	2.96
0.30	3.47	3.13
0.40	3.59	3.23
0.50	3.53	3.17
0.75	3.07	2.73
1.00	2.60	2.30
1.50	1.79	1.58
2.00	1.34	1.18
3.00	0.92	0.81
4.00	0.68	0.60
5.00	0.54	0.48
7.50	0.29	0.26
10.00	0.18	0.16



S <sub>s</sub> =	3.02	2.73
S <sub>r</sub> =	2.60	2.30
PGA	1.24 g	

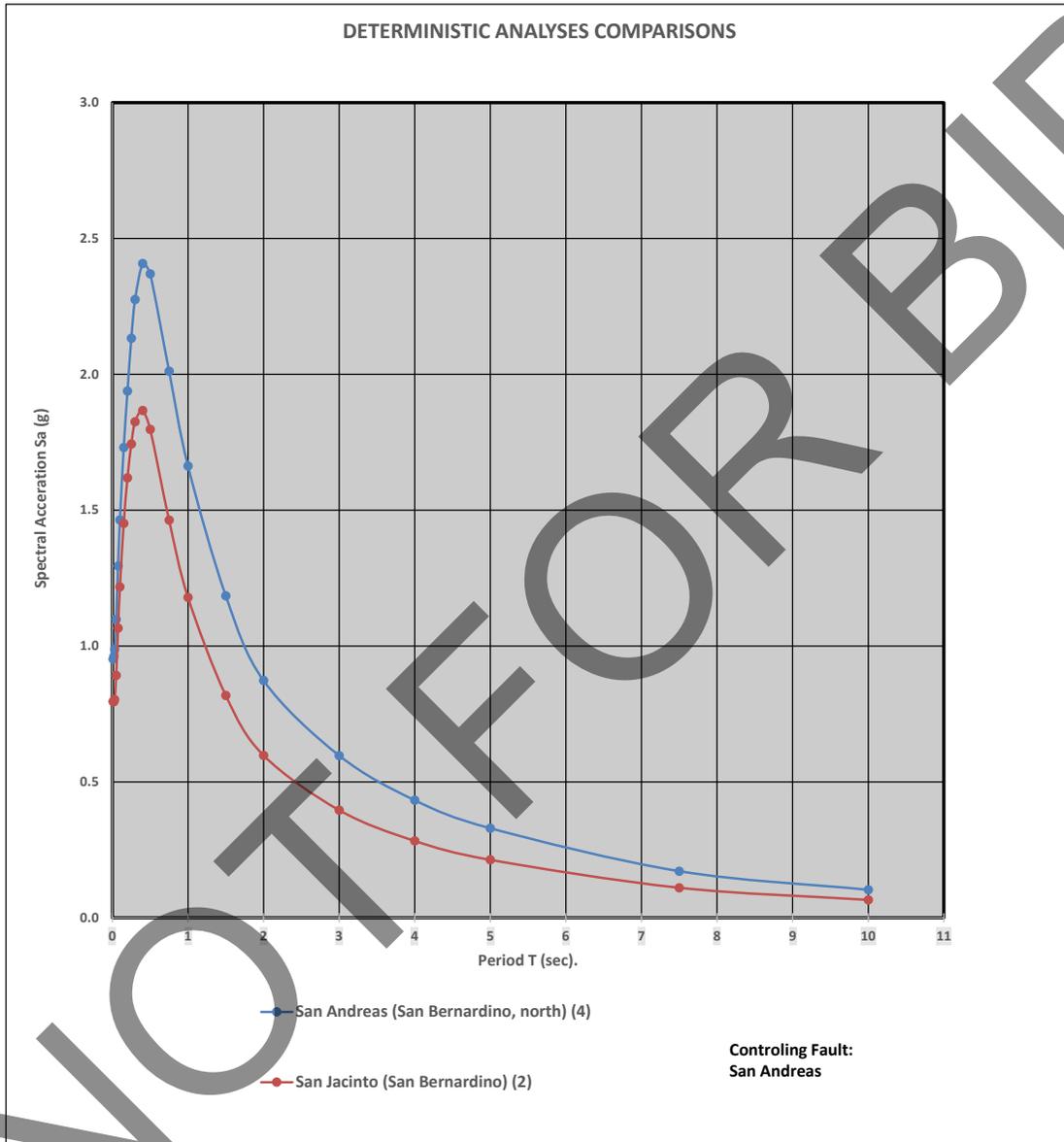
Risk Coefficients:		
C <sub>RS</sub>	0.905	Figure 22-18
C <sub>R1</sub>	0.884	Figure 22-19
F <sub>a</sub> =	1	Table 11.4-1
Is Sa <sub>(max)</sub> < 1.2XF <sub>a</sub> ?	NO	If "YES", Probabilistic Spectrum prevails

**DETERMINISTIC MCE per 21.2.2**

**Preliminary Assessment:**

Fault	Distance (km)
San Andreas (San Bernardino, north) (4)	1.80
San Jacinto (San Bernardino) (2)	6.30

The Probabilistic Analyses revealed 5 faults contributing more than 10% to the seismic hazard. These were considered in the Deterministic Analyses along with the Newport-Inglewood Fault.



Input Parameters		San Andreas (San Bernardino, north) (4)	San Jacinto (San Bernardino) (2)
<b>Fault</b>			
<b>M</b>	= Moment magnitude	8.1	7.8
<b>R<sub>RUP</sub></b>	= Closest distance to coseismic rupture (km)	1.8	6.3
<b>R<sub>JB</sub></b>	= Closest distance to surface projection of coseismic rupture (km)	1.8	6.3
<b>R<sub>x</sub></b>	= Horizontal distance to top edge of rupture measured perpendicular to strike (km)	1.8	6.3
<b>U</b>	= Unspecified Faulting Flag (Boore et.al.)	0	0
<b>F<sub>RV</sub></b>	= Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust	0	0
<b>F<sub>NM</sub></b>	= Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique and thrust; 1 for normal and normal-oblique	0	0
<b>F<sub>HW</sub></b>	= Hanging-wall factor: 1 for site on down-dip side of top of rupture; 0 otherwise, used in AS08 and CY08	0	0
<b>Z<sub>TOR</sub></b>	= Depth to top of coseismic rupture (km)	0	0
<b>δ</b>	= Average dip of rupture plane (degrees)	90	90
<b>V<sub>S30</sub></b>	= Average shear-wave velocity in top 30m of site profile	327.7	327.7
<b>F<sub>Measured</sub></b>		1	1
<b>Z<sub>1.0</sub></b>	= Depth to Shear Wave Velocity of 1.0 km/sec (km)	0.25	0.25
<b>Z<sub>2.5</sub></b>	= Depth to Shear Wave Velocity of 2.5 km/sec (km)	0.35	0.35
<b>Site Class</b>		D	D
<b>W (km)</b>	= Fault rupture width (km)	12.5	16.5
<b>F<sub>AS</sub></b>	= 0 for mainshock; 1 for aftershock	0	0
<b>σ</b>	=Standard Deviation	1	1

**Deterministic Summary - Section 21.2.2 (Supplement 1)**

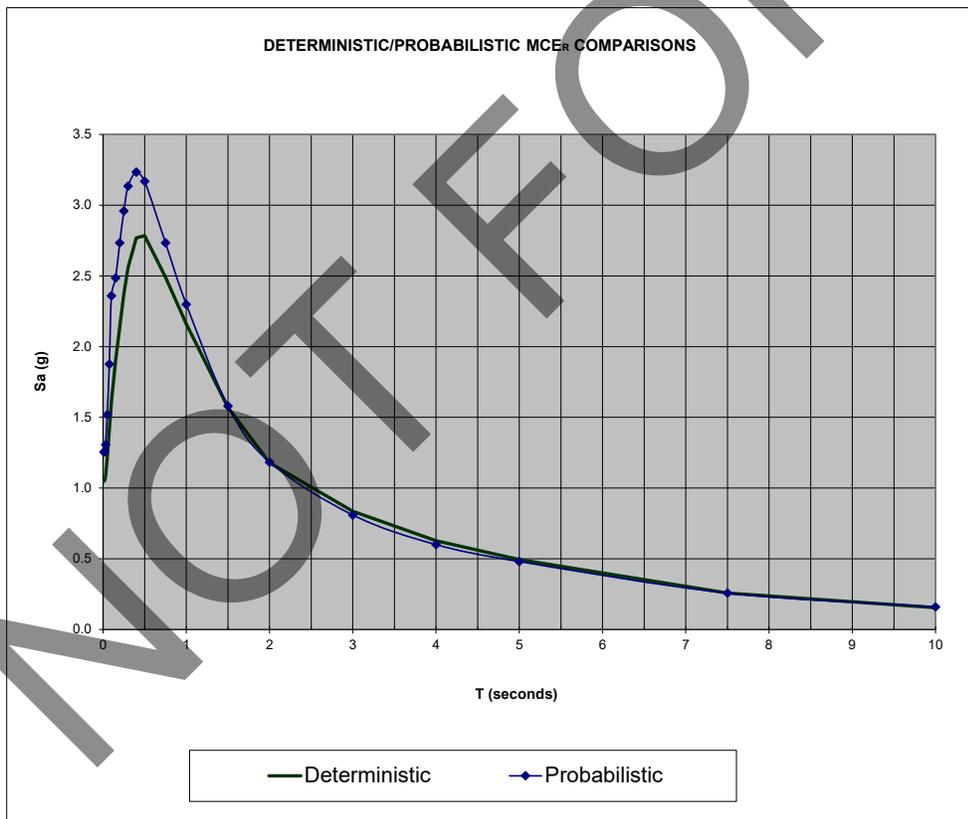
T	San Andreas (San Bernardino, north) (4)	San Jacinto (San Bernardino) (2)	Maximum S <sub>a</sub> (Average)	Corrected* S <sub>a</sub> (per ASCE7-16)	Scaled S <sub>a</sub> (Average)	Controlling Fault
0.010	0.95	0.80	0.95	1.05	1.05	San Andreas (San
0.020	0.96	0.79	0.96	1.06	1.06	San Andreas (San
0.030	0.99	0.80	0.99	1.09	1.09	San Andreas (San
0.050	1.10	0.89	1.10	1.21	1.21	San Andreas (San
0.075	1.29	1.07	1.29	1.42	1.42	San Andreas (San
0.100	1.46	1.22	1.46	1.61	1.61	San Andreas (San
0.150	1.73	1.45	1.73	1.90	1.90	San Andreas (San
0.200	1.94	1.62	1.94	2.13	2.13	San Andreas (San
0.250	2.13	1.74	2.13	2.37	2.37	San Andreas (San
0.300	2.28	1.83	2.28	2.56	2.56	San Andreas (San
0.400	2.41	1.87	2.41	2.77	2.77	San Andreas (San
0.500	2.37	1.80	2.37	2.78	2.78	San Andreas (San
0.750	2.01	1.46	2.01	2.49	2.49	San Andreas (San
1.000	1.66	1.18	1.66	2.16	2.16	San Andreas (San
1.500	1.19	0.82	1.19	1.57	1.57	San Andreas (San
2.000	0.87	0.60	0.87	1.18	1.18	San Andreas (San
3.000	0.60	0.40	0.60	0.84	0.84	San Andreas (San
4.000	0.43	0.28	0.43	0.63	0.63	San Andreas (San
5.000	0.33	0.21	0.33	0.49	0.49	San Andreas (San
7.500	0.17	0.11	0.17	0.26	0.26	San Andreas (San
10.000	0.10	0.07	0.10	0.15	0.15	San Andreas (San
PGA	0.95	0.76	0.95		0.95	g
Max Sa=	2.78					
Fa =	1.00					Per ASCE7-16 21.2.2
1.5XFa=	1.5					
Scaling						
Factor=	1.00					

\* Correction is the adjustment for Maximum Rotated Value if Applicable

**SITE SPECIFIC MCE<sub>R</sub> - Compare Deterministic MCE<sub>R</sub> Values (S<sub>a</sub>) with Probabilistic MCE<sub>R</sub> Values (S<sub>a</sub>) per 21.2.3**

Presented data are the average of Chiou & Youngs (2014), Abrahamson et. al. (2014) , Boore et. al (2014) and Campbell & Bozorgnia (2014) NGA West-2 Relat

Period	Deterministic	Probabilistic	Lower Value (Site Specific MCE <sub>R</sub> )	Governing Method
T	MCE <sub>R</sub>	MCE <sub>R</sub>		
0.010	1.05	1.25	1.05	Deterministic Governs
0.020	1.06	1.26	1.06	Deterministic Governs
0.030	1.09	1.31	1.09	Deterministic Governs
0.050	1.21	1.52	1.21	Deterministic Governs
0.075	1.42	1.88	1.42	Deterministic Governs
0.100	1.61	2.36	1.61	Deterministic Governs
0.150	1.90	2.49	1.90	Deterministic Governs
0.200	2.13	2.73	2.13	Deterministic Governs
0.250	2.37	2.96	2.37	Deterministic Governs
0.300	2.56	3.13	2.56	Deterministic Governs
0.400	2.77	3.23	2.77	Deterministic Governs
0.500	2.78	3.17	2.78	Deterministic Governs
0.750	2.49	2.73	2.49	Deterministic Governs
1.000	2.16	2.30	2.16	Deterministic Governs
1.500	1.57	1.58	1.57	Deterministic Governs
2.000	1.18	1.18	1.18	Deterministic Governs
3.000	0.84	0.81	0.81	Probabilistic Governs
4.000	0.63	0.60	0.60	Probabilistic Governs
5.000	0.49	0.48	0.48	Probabilistic Governs
7.500	0.26	0.26	0.26	Deterministic Governs
10.000	0.15	0.16	0.15	Deterministic Governs



DESIGN RESPONSE SPECTRUM per Section 21.3

DESIGN ACCELERATION PARAMETERS per Section 21.4 (MRSA)

Period	$2/3 \cdot MCE_R$	80% General Design Response Spectrum (per ASCE 7-16 23.3-1)	Design Response Spectrum	TXSa
0.01	0.70	0.57	0.70	
0.02	0.71	0.61	0.71	
0.03	0.72	0.65	0.72	
0.05	0.81	0.74	0.81	
0.08	0.95	0.84	0.95	
0.10	1.07	0.94	1.07	
0.15	1.27	1.14	1.27	
0.20	1.42	1.34	1.42	
0.25	1.58	1.34	1.58	
0.30	1.71	1.34	1.71	
0.40	1.85	1.34	1.85	
0.50	1.86	1.34	1.86	
0.75	1.66	1.34	1.66	
1.00	1.44	1.34	1.44	1.44
1.50	1.05	0.89	1.05	1.57
2.00	0.79	0.67	0.79	1.57
3.00	0.54	0.45	0.54	1.62
4.00	0.40	0.33	0.40	1.60
5.00	0.32	0.27	0.32	1.60
7.50	0.17	0.18	0.18	
10.00	0.10	0.11	0.11	

Highest value of  $S_a$  for any period exceeding 0.2 sec. = 1.86  
 90% of Highest Value = 1.67  
 80% of Mapped  $S_{DS}$  = 1.34  
Maximum TXSa from  $T=1s-5s$  = 1.62  
 80% of Mapped  $S_{D1}$  = 0.91

$S_{DS}$ =	1.67
$S_{D1}$ =	1.62
$T_s$ =	0.97

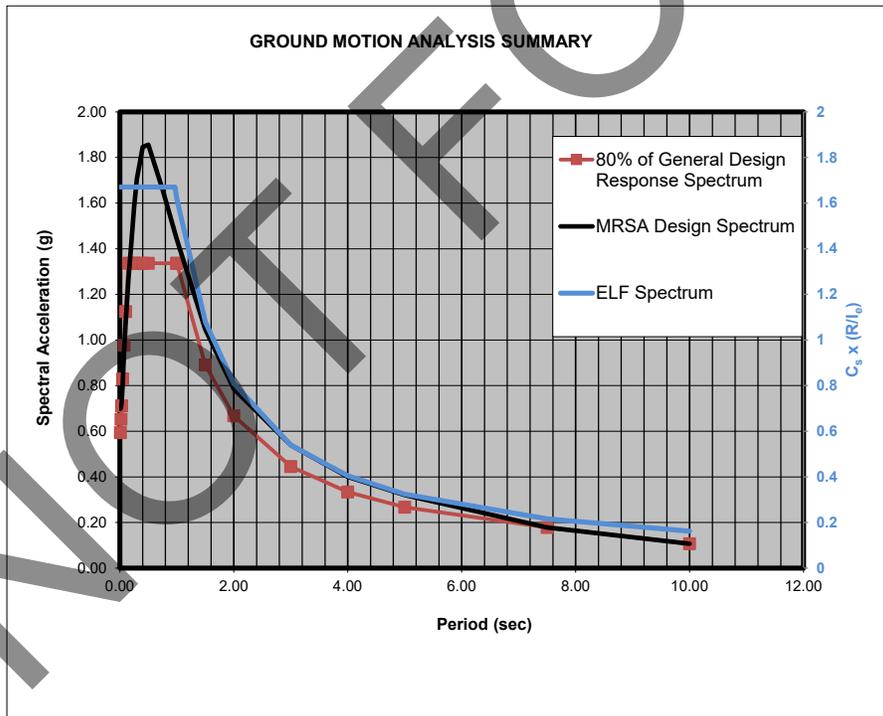
$S_{MS}$ =	2.506
$S_{M1}$ =	2.429

PGA Determination:

Site Coefficient $F_{PGA}$ =	1.1
Mapped PGA =	1.04
$PGA_M$ =	1.14 g

Figure 22-7

Deterministic PGA =	0.95 g
Probabilistic PGA =	1.24 g
Lesser of Deterministic/Probabilistic =	0.95 g
80% of $PGA_M$ =	0.92 g
$MCE_G$ PGA =	0.95 g



**SUMMARY OF SITE SPECIFIC GROUND MOTION HAZARD ANALYSIS DATA**

1	2	3		4	5	6	7	8	9	10	11	12
Period (sec)	Mapped MCE <sub>R</sub> Spectrum	Mapped Design Spectrum	Period (sec)	Risk Coefficient C <sub>R</sub>	Scaled MCE <sub>R</sub> Deterministic Spectrum	Probabilistic MCE <sub>R</sub> Spectrum	Probabilistic w/Risk Coefficient C <sub>R</sub>	84th Percentile Deterministic Spectrum	2/3 Site Specific MCE <sub>R</sub> Spectrum	80% of General Design Spectrum	Site Specific MCE <sub>R</sub> Spectrum	Design Response Spectrum
0.01	1.00	0.67	0.01	0.905	1.05	1.25	1.25	1.05	0.70	0.57	1.05	0.70
0.14	2.51	1.67	0.02	0.905	1.06	1.26	1.26	1.06	0.71	0.61	1.06	0.71
0.20	2.51	1.67	0.03	0.905	1.09	1.31	1.31	1.09	0.72	0.65	1.09	0.72
0.68	2.51	1.67	0.05	0.905	1.21	1.52	1.52	1.21	0.81	0.74	1.21	0.81
0.70	2.43	1.62	0.08	0.905	1.42	1.88	1.88	1.42	0.95	0.84	1.42	0.95
0.80	2.13	1.42	0.10	0.905	1.61	2.36	2.36	1.61	1.07	0.94	1.61	1.07
0.90	1.89	1.26	0.15	0.905	1.90	2.49	2.49	1.90	1.27	1.14	1.90	1.27
1.00	1.70	1.14	0.20	0.905	2.13	2.73	2.73	2.13	1.42	1.34	2.13	1.42
1.10	1.55	1.03	0.25	0.904	2.37	2.96	2.96	2.37	1.58	1.34	2.37	1.58
1.20	1.42	0.95	0.30	0.902	2.56	3.13	3.13	2.56	1.71	1.34	2.56	1.71
1.30	1.31	0.87	0.40	0.900	2.77	3.23	3.23	2.77	1.85	1.34	2.77	1.85
1.40	1.22	0.81	0.50	0.897	2.78	3.17	3.17	2.78	1.86	1.34	2.78	1.86
1.50	1.14	0.76	0.75	0.891	2.49	2.73	2.73	2.49	1.66	1.34	2.49	1.66
1.60	1.06	0.71	1.00	0.884	2.16	2.30	2.30	2.16	1.44	1.34	2.16	1.44
1.70	1.00	0.67	1.50	0.884	1.57	1.58	1.58	1.57	1.05	0.89	1.57	1.05
1.80	0.95	0.63	2.00	0.884	1.18	1.18	1.18	1.18	0.79	0.67	1.18	0.79
1.90	0.90	0.60	3.00	0.884	0.84	0.81	0.81	0.84	0.54	0.45	0.81	0.54
2.00	0.85	0.57	4.00	0.884	0.63	0.60	0.60	0.63	0.40	0.33	0.60	0.40
3.00	0.57	0.38	5.00	0.884	0.49	0.48	0.48	0.49	0.32	0.27	0.48	0.32
4.00	0.43	0.28	7.50	0.884	0.26	0.26	0.26	0.26	0.17	0.18	0.27	0.18
5.00	0.34	0.23	10.00	0.884	0.15	0.16	0.16	0.15	0.10	0.11	0.16	0.11
7.50	0.23	0.15										
10.00	0.14	0.09										

# APPENDIX C

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a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for San Bernardino County Southwestern Part, California



# Preface

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Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

## Custom Soil Resource Report

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

## Custom Soil Resource Report

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

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## Soil Map

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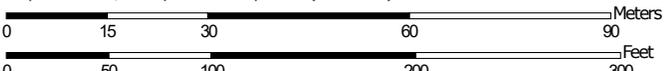
The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

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Soil Map



Map Scale: 1:1,120 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84



### MAP LEGEND

- Area of Interest (AOI)**
  -  Area of Interest (AOI)
- Soils**
  -  Soil Map Unit Polygons
  -  Soil Map Unit Lines
  -  Soil Map Unit Points
- Special Point Features**
  -  Blowout
  -  Borrow Pit
  -  Clay Spot
  -  Closed Depression
  -  Gravel Pit
  -  Gravelly Spot
  -  Landfill
  -  Lava Flow
  -  Marsh or swamp
  -  Mine or Quarry
  -  Miscellaneous Water
  -  Perennial Water
  -  Rock Outcrop
  -  Saline Spot
  -  Sandy Spot
  -  Severely Eroded Spot
  -  Sinkhole
  -  Slide or Slip
  -  Sodic Spot
- Water Features**
  -  Streams and Canals
- Transportation**
  -  Rails
  -  Interstate Highways
  -  US Routes
  -  Major Roads
  -  Local Roads
- Background**
  -  Aerial Photography
-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Bernardino County Southwestern Part, California  
 Survey Area Data: Version 16, Aug 30, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 17, 2022—Jun 12, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

**MAP LEGEND**

**MAP INFORMATION**

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

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## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HaC	Hanford coarse sandy loam, 2 to 9 percent slopes	4.1	100.0%
<b>Totals for Area of Interest</b>		<b>4.1</b>	<b>100.0%</b>

## Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

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An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

## San Bernardino County Southwestern Part, California

### HaC—Hanford coarse sandy loam, 2 to 9 percent slopes

#### Map Unit Setting

*National map unit symbol:* 2y8tl  
*Elevation:* 890 to 2,860 feet  
*Mean annual precipitation:* 11 to 22 inches  
*Mean annual air temperature:* 64 to 65 degrees F  
*Frost-free period:* 320 to 365 days  
*Farmland classification:* Prime farmland if irrigated

#### Map Unit Composition

*Hanford and similar soils:* 85 percent  
*Minor components:* 15 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Hanford

##### Setting

*Landform:* Alluvial fans  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Alluvium derived from granite

##### Typical profile

*A - 0 to 12 inches:* sandy loam  
*C - 12 to 60 inches:* fine sandy loam

##### Properties and qualities

*Slope:* 2 to 9 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* Low  
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 5.95 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* Rare  
*Frequency of ponding:* None  
*Maximum salinity:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water supply, 0 to 60 inches:* Moderate (about 7.8 inches)

##### Interpretive groups

*Land capability classification (irrigated):* 2e  
*Land capability classification (nonirrigated):* 3e  
*Hydrologic Soil Group:* A  
*Ecological site:* R019XG911CA - Loamy Fan  
*Hydric soil rating:* No

#### Minor Components

##### Greenfield, sandy loam

*Percent of map unit:* 10 percent  
*Landform:* Alluvial fans  
*Landform position (three-dimensional):* Tread

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*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Hydric soil rating:* No

**Tujungang, loamy sand**

*Percent of map unit:* 5 percent  
*Landform:* Alluvial fans  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Hydric soil rating:* No

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# Glossary

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Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "[National Soil Survey Handbook](#)."

## **ABC soil**

A soil having an A, a B, and a C horizon.

## **Ablation till**

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

## **AC soil**

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

## **Aeration, soil**

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

## **Aggregate, soil**

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

## **Alkali (sodic) soil**

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

## **Alluvial cone**

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

**Alluvial fan**

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

**Alluvium**

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

**Alpha,alpha-dipyridyl**

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

**Animal unit month (AUM)**

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

**Aquic conditions**

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

**Argillic horizon**

A subsoil horizon characterized by an accumulation of illuvial clay.

**Arroyo**

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

**Aspect**

The direction toward which a slope faces. Also called slope aspect.

**Association, soil**

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

**Available water capacity (available moisture capacity)**

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

*Very low:* 0 to 3

*Low:* 3 to 6

*Moderate:* 6 to 9

*High:* 9 to 12

*Very high:* More than 12

### **Backslope**

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

### **Backswamp**

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

### **Badland**

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

### **Bajada**

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

### **Basal area**

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

### **Base saturation**

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

### **Base slope (geomorphology)**

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

### **Bedding plane**

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology)

from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

**Bedding system**

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

**Bedrock**

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

**Bedrock-controlled topography**

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

**Bench terrace**

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

**Bisequum**

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

**Blowout (map symbol)**

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

**Borrow pit (map symbol)**

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

**Bottom land**

An informal term loosely applied to various portions of a flood plain.

**Boulders**

Rock fragments larger than 2 feet (60 centimeters) in diameter.

**Breaks**

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

**Breast height**

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

**Brush management**

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

**Butte**

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

**Cable yarding**

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

**Calcareous soil**

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

**Caliche**

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

**California bearing ratio (CBR)**

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

**Canopy**

The leafy crown of trees or shrubs. (See Crown.)

**Canyon**

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

**Capillary water**

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

**Catena**

A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

**Cation**

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

**Cation-exchange capacity**

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

**Catsteps**

See Terracettes.

**Cement rock**

Shaly limestone used in the manufacture of cement.

**Channery soil material**

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

**Chemical treatment**

Control of unwanted vegetation through the use of chemicals.

**Chiseling**

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

**Cirque**

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

**Clay**

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Clay depletions**

See Redoximorphic features.

**Clay film**

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

**Clay spot (map symbol)**

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

**Claypan**

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

**Climax plant community**

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

**Coarse textured soil**

Sand or loamy sand.

**Cobble (or cobblestone)**

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

**Cobbly soil material**

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

**COLE (coefficient of linear extensibility)**

See Linear extensibility.

**Colluvium**

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

**Complex slope**

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

**Complex, soil**

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

**Concretions**

See Redoximorphic features.

**Conglomerate**

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

**Conservation cropping system**

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

**Conservation tillage**

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

**Consistence, soil**

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

**Contour stripcropping**

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

**Control section**

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

**Coprogenous earth (sedimentary peat)**

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

**Corrosion (geomorphology)**

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

**Corrosion (soil survey interpretations)**

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

**Cover crop**

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

**Crop residue management**

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

**Cropping system**

Growing crops according to a planned system of rotation and management practices.

**Cross-slope farming**

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

**Crown**

The upper part of a tree or shrub, including the living branches and their foliage.

**Cryoturbate**

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

**Cuesta**

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

**Culmination of the mean annual increment (CMAI)**

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

**Cutbanks cave**

The walls of excavations tend to cave in or slough.

**Decreasers**

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

**Deferred grazing**

Postponing grazing or resting grazing land for a prescribed period.

**Delta**

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

**Dense layer**

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

**Depression, closed (map symbol)**

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

**Depth, soil**

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

**Desert pavement**

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

**Diatomaceous earth**

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

**Dip slope**

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

**Diversion (or diversion terrace)**

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

**Divided-slope farming**

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

**Drainage class (natural)**

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained*. These classes are defined in the “Soil Survey Manual.”

**Drainage, surface**

Runoff, or surface flow of water, from an area.

**Drainageway**

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

**Draw**

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

**Drift**

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

**Drumlin**

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

**Duff**

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

**Dune**

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

**Earthy fill**

See Mine spoil.

**Ecological site**

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

**Eluviation**

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

**Endosaturation**

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

**Eolian deposit**

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

**Ephemeral stream**

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

**Episaturation**

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

**Erosion**

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

**Erosion (accelerated)**

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

**Erosion (geologic)**

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

**Erosion pavement**

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

**Erosion surface**

A land surface shaped by the action of erosion, especially by running water.

**Escarpment**

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

**Escarpment, bedrock (map symbol)**

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

**Escarpment, nonbedrock (map symbol)**

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

**Esker**

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left

behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

**Extrusive rock**

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

**Fallow**

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

**Fan remnant**

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

**Fertility, soil**

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

**Fibric soil material (peat)**

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

**Field moisture capacity**

The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity*, *normal moisture capacity*, or *capillary capacity*.

**Fill slope**

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

**Fine textured soil**

Sandy clay, silty clay, or clay.

**Firebreak**

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

**First bottom**

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

**Flaggy soil material**

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

**Flagstone**

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

**Flood plain**

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

**Flood-plain landforms**

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

**Flood-plain splay**

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

**Flood-plain step**

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

**Fluvial**

Of or pertaining to rivers or streams; produced by stream or river action.

**Foothills**

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

**Footslope**

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

**Forb**

Any herbaceous plant not a grass or a sedge.

**Forest cover**

All trees and other woody plants (underbrush) covering the ground in a forest.

**Forest type**

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

**Fragipan**

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

**Genesis, soil**

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

**Gilgai**

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

**Glaciofluvial deposits**

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

**Glaciolacustrine deposits**

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

**Gleyed soil**

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

**Graded stripcropping**

Growing crops in strips that grade toward a protected waterway.

**Grassed waterway**

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

**Gravel**

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

**Gravel pit (map symbol)**

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

**Gravelly soil material**

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

**Gravelly spot (map symbol)**

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

**Green manure crop (agronomy)**

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

**Ground water**

Water filling all the unblocked pores of the material below the water table.

**Gully (map symbol)**

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

**Hard bedrock**

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

**Hard to reclaim**

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

**Hardpan**

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

**Head slope (geomorphology)**

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

**Hemic soil material (mucky peat)**

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

**High-residue crops**

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

**Hill**

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

**Hillslope**

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

**Horizon, soil**

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the "Soil Survey Manual." The major horizons of mineral soil are as follows:

*O horizon:* An organic layer of fresh and decaying plant residue.

*L horizon:* A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

*A horizon:* The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

*E horizon:* The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

*B horizon:* The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

*C horizon:* The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

*Cr horizon:* Soft, consolidated bedrock beneath the soil.

*R layer:* Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

*M layer:* A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

*W layer:* A layer of water within or beneath the soil.

### **Humus**

The well decomposed, more or less stable part of the organic matter in mineral soils.

### **Hydrologic soil groups**

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

### **Igneous rock**

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

### **Illuviation**

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

**Impervious soil**

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

**Increasesers**

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasesers commonly are the shorter plants and the less palatable to livestock.

**Infiltration**

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

**Infiltration capacity**

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

**Infiltration rate**

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

**Intake rate**

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

- Very low:* Less than 0.2
- Low:* 0.2 to 0.4
- Moderately low:* 0.4 to 0.75
- Moderate:* 0.75 to 1.25
- Moderately high:* 1.25 to 1.75
- High:* 1.75 to 2.5
- Very high:* More than 2.5

**Interfluve**

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

**Interfluve (geomorphology)**

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

### **Intermittent stream**

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

### **Invaders**

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

### **Iron depletions**

See Redoximorphic features.

### **Irrigation**

Application of water to soils to assist in production of crops. Methods of irrigation are:

*Basin:* Water is applied rapidly to nearly level plains surrounded by levees or dikes.

*Border:* Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

*Controlled flooding:* Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

*Corrugation:* Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

*Drip (or trickle):* Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

*Furrow:* Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

*Sprinkler:* Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

*Subirrigation:* Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

*Wild flooding:* Water, released at high points, is allowed to flow onto an area without controlled distribution.

### **Kame**

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

**Karst (topography)**

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

**Knoll**

A small, low, rounded hill rising above adjacent landforms.

**Ksat**

See Saturated hydraulic conductivity.

**Lacustrine deposit**

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

**Lake plain**

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

**Lake terrace**

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

**Landfill (map symbol)**

An area of accumulated waste products of human habitation, either above or below natural ground level.

**Landslide**

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

**Large stones**

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

**Lava flow (map symbol)**

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

**Leaching**

The removal of soluble material from soil or other material by percolating water.

**Levee (map symbol)**

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

**Linear extensibility**

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at  $1/3$ - or  $1/10$ -bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

**Liquid limit**

The moisture content at which the soil passes from a plastic to a liquid state.

**Loam**

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

**Loess**

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

**Low strength**

The soil is not strong enough to support loads.

**Low-residue crops**

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

**Marl**

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

**Marsh or swamp (map symbol)**

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

**Mass movement**

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

**Masses**

See Redoximorphic features.

**Meander belt**

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

**Meander scar**

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

**Meander scroll**

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

**Mechanical treatment**

Use of mechanical equipment for seeding, brush management, and other management practices.

**Medium textured soil**

Very fine sandy loam, loam, silt loam, or silt.

**Mesa**

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

**Metamorphic rock**

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

**Mine or quarry (map symbol)**

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

**Mine spoil**

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

**Mineral soil**

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

**Minimum tillage**

Only the tillage essential to crop production and prevention of soil damage.

**Miscellaneous area**

A kind of map unit that has little or no natural soil and supports little or no vegetation.

**Miscellaneous water (map symbol)**

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

**Moderately coarse textured soil**

Coarse sandy loam, sandy loam, or fine sandy loam.

**Moderately fine textured soil**

Clay loam, sandy clay loam, or silty clay loam.

**Mollic epipedon**

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

**Moraine**

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

**Morphology, soil**

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

**Mottling, soil**

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

**Mountain**

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can

occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

**Muck**

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

**Mucky peat**

See Hemic soil material.

**Mudstone**

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

**Munsell notation**

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

**Natric horizon**

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

**Neutral soil**

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

**Nodules**

See Redoximorphic features.

**Nose slope (geomorphology)**

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

**Nutrient, plant**

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

**Organic matter**

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

*Very low:* Less than 0.5 percent

*Low:* 0.5 to 1.0 percent

*Moderately low:* 1.0 to 2.0 percent

*Moderate:* 2.0 to 4.0 percent

*High:* 4.0 to 8.0 percent

*Very high:* More than 8.0 percent

**Outwash**

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

**Outwash plain**

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

**Paleoterrace**

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

**Pan**

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan*, *fragipan*, *claypan*, *plowpan*, and *traffic pan*.

**Parent material**

The unconsolidated organic and mineral material in which soil forms.

**Peat**

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

**Ped**

An individual natural soil aggregate, such as a granule, a prism, or a block.

**Pedisediment**

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

**Pedon**

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

**Percolation**

The movement of water through the soil.

**Perennial water (map symbol)**

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

**Permafrost**

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

**pH value**

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

**Phase, soil**

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

**Piping**

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

**Pitting**

Pits caused by melting around ice. They form on the soil after plant cover is removed.

**Plastic limit**

The moisture content at which a soil changes from semisolid to plastic.

**Plasticity index**

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

**Plateau (geomorphology)**

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

**Playa**

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

**Plinthite**

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

**Plowpan**

A compacted layer formed in the soil directly below the plowed layer.

**Ponding**

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

**Poorly graded**

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

**Pore linings**

See Redoximorphic features.

**Potential native plant community**

See Climax plant community.

**Potential rooting depth (effective rooting depth)**

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

**Prescribed burning**

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

**Productivity, soil**

The capability of a soil for producing a specified plant or sequence of plants under specific management.

**Profile, soil**

A vertical section of the soil extending through all its horizons and into the parent material.

**Proper grazing use**

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and

promotes the accumulation of litter and mulch necessary to conserve soil and water.

### **Rangeland**

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

### **Reaction, soil**

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

*Ultra acid:* Less than 3.5

*Extremely acid:* 3.5 to 4.4

*Very strongly acid:* 4.5 to 5.0

*Strongly acid:* 5.1 to 5.5

*Moderately acid:* 5.6 to 6.0

*Slightly acid:* 6.1 to 6.5

*Neutral:* 6.6 to 7.3

*Slightly alkaline:* 7.4 to 7.8

*Moderately alkaline:* 7.9 to 8.4

*Strongly alkaline:* 8.5 to 9.0

*Very strongly alkaline:* 9.1 and higher

### **Red beds**

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

### **Redoximorphic concentrations**

See Redoximorphic features.

### **Redoximorphic depletions**

See Redoximorphic features.

### **Redoximorphic features**

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
  - A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
  - B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
  - C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
  - A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
  - B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

**Reduced matrix**

See Redoximorphic features.

**Regolith**

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

**Relief**

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

**Residuum (residual soil material)**

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

**Rill**

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

**Riser**

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

**Road cut**

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

**Rock fragments**

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

**Rock outcrop (map symbol)**

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where "Rock outcrop" is a named component of the map unit.

**Root zone**

The part of the soil that can be penetrated by plant roots.

**Runoff**

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

**Saline soil**

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

**Saline spot (map symbol)**

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

**Sand**

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

**Sandstone**

Sedimentary rock containing dominantly sand-sized particles.

**Sandy spot (map symbol)**

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

**Sapric soil material (muck)**

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

**Saturated hydraulic conductivity (Ksat)**

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

*Very high:* 100 or more micrometers per second (14.17 or more inches per hour)

*High:* 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

*Moderately high:* 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

*Moderately low:* 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

*Low:* 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

*Very low:* Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

**Saturation**

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

**Scarification**

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

**Sedimentary rock**

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

**Sequum**

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

**Series, soil**

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

**Severely eroded spot (map symbol)**

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which "severely eroded," "very severely eroded," or "gullied" is part of the map unit name.

**Shale**

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

**Sheet erosion**

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

**Short, steep slope (map symbol)**

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

**Shoulder**

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

**Shrink-swell**

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

**Shrub-coppice dune**

A small, streamlined dune that forms around brush and clump vegetation.

**Side slope (geomorphology)**

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

**Silica**

A combination of silicon and oxygen. The mineral form is called quartz.

**Silica-sesquioxide ratio**

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

**Silt**

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

**Siltstone**

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

**Similar soils**

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

**Sinkhole (map symbol)**

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

**Site index**

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

**Slickensides (pedogenic)**

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

**Slide or slip (map symbol)**

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

**Slope**

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

**Slope alluvium**

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

**Slow refill**

The slow filling of ponds, resulting from restricted water transmission in the soil.

**Slow water movement**

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

**Sodic (alkali) soil**

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

**Sodic spot (map symbol)**

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

**Sodicity**

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of  $\text{Na}^+$  to  $\text{Ca}^{++} + \text{Mg}^{++}$ . The degrees of sodicity and their respective ratios are:

*Slight:* Less than 13:1

*Moderate:* 13-30:1

*Strong:* More than 30:1

**Sodium adsorption ratio (SAR)**

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

**Soft bedrock**

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

**Soil**

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

**Soil separates**

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

*Very coarse sand:* 2.0 to 1.0

*Coarse sand:* 1.0 to 0.5

*Medium sand:* 0.5 to 0.25

*Fine sand:* 0.25 to 0.10

*Very fine sand:* 0.10 to 0.05

*Silt:* 0.05 to 0.002

*Clay:* Less than 0.002

**Solum**

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

**Spoil area (map symbol)**

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

**Stone line**

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

**Stones**

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

**Stony**

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

**Stony spot (map symbol)**

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

**Strath terrace**

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

**Stream terrace**

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

**Stripcropping**

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

**Structure, soil**

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

*Platy*: Flat and laminated

*Prismatic*: Vertically elongated and having flat tops

*Columnar*: Vertically elongated and having rounded tops

*Angular blocky*: Having faces that intersect at sharp angles (planes)

*Subangular blocky*: Having subrounded and planar faces (no sharp angles)

*Granular*: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

*Single grained*: Entirely noncoherent (each grain by itself), as in loose sand

*Massive*: Occurring as a coherent mass

**Stubble mulch**

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

**Subsoil**

Technically, the B horizon; roughly, the part of the solum below plow depth.

**Subsoiling**

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

**Substratum**

The part of the soil below the solum.

**Subsurface layer**

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

**Summer fallow**

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

**Summit**

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

**Surface layer**

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

**Surface soil**

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

**Talus**

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

**Taxadjuncts**

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

**Terminal moraine**

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

**Terrace (conservation)**

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field

generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

**Terrace (geomorphology)**

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

**Terracettes**

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

**Texture, soil**

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Thin layer**

Otherwise suitable soil material that is too thin for the specified use.

**Till**

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

**Till plain**

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

**Tilth, soil**

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

**Toeslope**

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

**Topsoil**

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

**Trace elements**

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

**Tread**

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

**Tuff**

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

**Upland**

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

**Valley fill**

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

**Variiegation**

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

**Varve**

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

**Very stony spot (map symbol)**

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

**Water bars**

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

**Weathering**

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

**Well graded**

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

**Wet spot (map symbol)**

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

**Wilting point (or permanent wilting point)**

The moisture content of soil, on an oven-dry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

**Windthrow**

The uprooting and tipping over of trees by the wind.

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APPENDIX 2. FEMA FLOOD INSURANCE  
STUDY

# National Flood Hazard Layer FIRMMette



117°17'32"W 34°9'50"N



1:6,000 117°16'54"W 34°9'21"N

Basemap Imagery Source: USGS National Map 2023

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

- SPECIAL FLOOD HAZARD AREAS**
  - Without Base Flood Elevation (BFE)  
*Zone A, V, A99*
  - With BFE or Depth *Zone AE, AO, AH, VE, AR*
  - Regulatory Floodway
  
- OTHER AREAS OF FLOOD HAZARD**
  - 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
  - Future Conditions 1% Annual Chance Flood Hazard *Zone X*
  - Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
  - Area with Flood Risk due to Levee *Zone D*
  
- OTHER AREAS**
  - NO SCREEN Area of Minimal Flood Hazard *Zone X*
  - Effective LOMRs
  - Area of Undetermined Flood Hazard *Zone D*
  
- GENERAL STRUCTURES**
  - Channel, Culvert, or Storm Sewer
  - Levee, Dike, or Floodwall
  
- OTHER FEATURES**
  - Cross Sections with 1% Annual Chance Water Surface Elevation
  - Coastal Transect
  - Base Flood Elevation Line (BFE)
  - Limit of Study
  - Jurisdiction Boundary
  - Coastal Transect Baseline
  - Profile Baseline
  - Hydrographic Feature
  
- MAP PANELS**
  - Digital Data Available
  - No Digital Data Available
  - Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **9/9/2024 at 7:12 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

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## APPENDIX 3. NOAA ATLAS 14



**NOAA Atlas 14, Volume 6, Version 2**  
**Location name: San Bernardino, California, USA\***  
**Latitude: 34.1604°, Longitude: -117.2866°**  
**Elevation: 1287 ft\*\***  
 \* source: ESRI Maps  
 \*\* source: USGS



**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

[PF tabular](#) | [PF graphical](#) | [Maps & aeriels](#)

**PF tabular**

<b>PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup></b>										
<b>Duration</b>	<b>Average recurrence interval (years)</b>									
	<b>1</b>	<b>2</b>	<b>5</b>	<b>10</b>	<b>25</b>	<b>50</b>	<b>100</b>	<b>200</b>	<b>500</b>	<b>1000</b>
<b>5-min</b>	<b>0.124</b> (0.103-0.151)	<b>0.165</b> (0.137-0.201)	<b>0.222</b> (0.184-0.271)	<b>0.273</b> (0.224-0.336)	<b>0.347</b> (0.275-0.441)	<b>0.408</b> (0.317-0.531)	<b>0.475</b> (0.360-0.633)	<b>0.548</b> (0.404-0.752)	<b>0.656</b> (0.463-0.939)	<b>0.747</b> (0.509-1.11)
<b>10-min</b>	<b>0.178</b> (0.148-0.217)	<b>0.237</b> (0.196-0.288)	<b>0.319</b> (0.264-0.389)	<b>0.391</b> (0.321-0.481)	<b>0.497</b> (0.394-0.633)	<b>0.585</b> (0.454-0.761)	<b>0.681</b> (0.516-0.908)	<b>0.786</b> (0.579-1.08)	<b>0.941</b> (0.664-1.35)	<b>1.07</b> (0.729-1.59)
<b>15-min</b>	<b>0.216</b> (0.179-0.262)	<b>0.286</b> (0.237-0.348)	<b>0.386</b> (0.319-0.470)	<b>0.473</b> (0.388-0.582)	<b>0.601</b> (0.477-0.765)	<b>0.707</b> (0.549-0.920)	<b>0.823</b> (0.623-1.10)	<b>0.951</b> (0.700-1.30)	<b>1.14</b> (0.803-1.63)	<b>1.30</b> (0.882-1.92)
<b>30-min</b>	<b>0.328</b> (0.273-0.398)	<b>0.435</b> (0.361-0.529)	<b>0.586</b> (0.485-0.715)	<b>0.718</b> (0.590-0.884)	<b>0.913</b> (0.724-1.16)	<b>1.08</b> (0.835-1.40)	<b>1.25</b> (0.947-1.67)	<b>1.44</b> (1.06-1.98)	<b>1.73</b> (1.22-2.47)	<b>1.97</b> (1.34-2.92)
<b>60-min</b>	<b>0.498</b> (0.414-0.605)	<b>0.660</b> (0.548-0.803)	<b>0.890</b> (0.737-1.09)	<b>1.09</b> (0.895-1.34)	<b>1.39</b> (1.10-1.76)	<b>1.63</b> (1.27-2.12)	<b>1.90</b> (1.44-2.53)	<b>2.19</b> (1.61-3.01)	<b>2.62</b> (1.85-3.76)	<b>2.99</b> (2.03-4.43)
<b>2-hr</b>	<b>0.741</b> (0.616-0.901)	<b>0.946</b> (0.785-1.15)	<b>1.22</b> (1.01-1.49)	<b>1.46</b> (1.20-1.80)	<b>1.80</b> (1.43-2.29)	<b>2.07</b> (1.60-2.69)	<b>2.35</b> (1.78-3.13)	<b>2.65</b> (1.95-3.64)	<b>3.08</b> (2.18-4.41)	<b>3.43</b> (2.34-5.09)
<b>3-hr</b>	<b>0.910</b> (0.757-1.11)	<b>1.14</b> (0.951-1.39)	<b>1.46</b> (1.21-1.78)	<b>1.72</b> (1.42-2.12)	<b>2.09</b> (1.66-2.67)	<b>2.39</b> (1.85-3.10)	<b>2.69</b> (2.04-3.58)	<b>3.01</b> (2.21-4.13)	<b>3.45</b> (2.44-4.94)	<b>3.81</b> (2.59-5.65)
<b>6-hr</b>	<b>1.31</b> (1.09-1.59)	<b>1.63</b> (1.35-1.98)	<b>2.05</b> (1.70-2.50)	<b>2.39</b> (1.96-2.94)	<b>2.87</b> (2.27-3.65)	<b>3.23</b> (2.51-4.20)	<b>3.60</b> (2.73-4.81)	<b>3.99</b> (2.94-5.48)	<b>4.52</b> (3.19-6.47)	<b>4.93</b> (3.36-7.31)
<b>12-hr</b>	<b>1.73</b> (1.43-2.10)	<b>2.16</b> (1.80-2.64)	<b>2.74</b> (2.27-3.34)	<b>3.21</b> (2.63-3.94)	<b>3.84</b> (3.04-4.88)	<b>4.32</b> (3.36-5.62)	<b>4.81</b> (3.64-6.41)	<b>5.31</b> (3.91-7.29)	<b>5.99</b> (4.22-8.57)	<b>6.51</b> (4.44-9.66)
<b>24-hr</b>	<b>2.31</b> (2.05-2.66)	<b>2.96</b> (2.62-3.41)	<b>3.81</b> (3.36-4.40)	<b>4.49</b> (3.93-5.24)	<b>5.42</b> (4.59-6.53)	<b>6.13</b> (5.09-7.54)	<b>6.85</b> (5.55-8.63)	<b>7.59</b> (5.98-9.82)	<b>8.58</b> (6.49-11.6)	<b>9.35</b> (6.84-13.0)
<b>2-day</b>	<b>2.80</b> (2.48-3.22)	<b>3.68</b> (3.26-4.25)	<b>4.84</b> (4.27-5.60)	<b>5.77</b> (5.05-6.73)	<b>7.04</b> (5.96-8.48)	<b>8.00</b> (6.64-9.84)	<b>8.98</b> (7.27-11.3)	<b>9.98</b> (7.86-12.9)	<b>11.3</b> (8.57-15.3)	<b>12.4</b> (9.04-17.2)
<b>3-day</b>	<b>3.04</b> (2.69-3.50)	<b>4.07</b> (3.60-4.70)	<b>5.42</b> (4.78-6.27)	<b>6.51</b> (5.70-7.59)	<b>7.99</b> (6.77-9.62)	<b>9.12</b> (7.57-11.2)	<b>10.3</b> (8.32-12.9)	<b>11.4</b> (9.02-14.8)	<b>13.0</b> (9.86-17.6)	<b>14.3</b> (10.4-19.9)
<b>4-day</b>	<b>3.22</b> (2.86-3.71)	<b>4.35</b> (3.85-5.02)	<b>5.83</b> (5.14-6.74)	<b>7.03</b> (6.16-8.20)	<b>8.68</b> (7.35-10.5)	<b>9.94</b> (8.25-12.2)	<b>11.2</b> (9.09-14.1)	<b>12.5</b> (9.89-16.2)	<b>14.3</b> (10.9-19.3)	<b>15.7</b> (11.5-22.0)
<b>7-day</b>	<b>3.66</b> (3.24-4.22)	<b>4.94</b> (4.37-5.69)	<b>6.64</b> (5.86-7.68)	<b>8.06</b> (7.06-9.40)	<b>10.0</b> (8.50-12.1)	<b>11.6</b> (9.61-14.2)	<b>13.2</b> (10.7-16.6)	<b>14.9</b> (11.7-19.3)	<b>17.2</b> (13.0-23.2)	<b>19.1</b> (13.9-26.6)
<b>10-day</b>	<b>4.05</b> (3.58-4.66)	<b>5.45</b> (4.82-6.29)	<b>7.36</b> (6.49-8.51)	<b>8.96</b> (7.84-10.4)	<b>11.2</b> (9.50-13.5)	<b>13.0</b> (10.8-16.0)	<b>14.9</b> (12.1-18.8)	<b>16.9</b> (13.3-21.9)	<b>19.7</b> (14.9-26.6)	<b>22.0</b> (16.1-30.6)
<b>20-day</b>	<b>5.05</b> (4.48-5.82)	<b>6.88</b> (6.09-7.94)	<b>9.39</b> (8.28-10.9)	<b>11.5</b> (10.1-13.4)	<b>14.6</b> (12.3-17.5)	<b>17.0</b> (14.1-20.9)	<b>19.6</b> (15.9-24.7)	<b>22.4</b> (17.6-28.9)	<b>26.3</b> (19.9-35.4)	<b>29.5</b> (21.6-41.1)
<b>30-day</b>	<b>5.90</b> (5.22-6.80)	<b>8.09</b> (7.16-9.33)	<b>11.1</b> (9.79-12.8)	<b>13.6</b> (11.9-15.9)	<b>17.3</b> (14.6-20.8)	<b>20.2</b> (16.8-24.9)	<b>23.3</b> (18.9-29.4)	<b>26.6</b> (21.0-34.5)	<b>31.3</b> (23.7-42.2)	<b>35.1</b> (25.7-49.0)
<b>45-day</b>	<b>7.09</b> (6.28-8.16)	<b>9.76</b> (8.63-11.3)	<b>13.4</b> (11.8-15.5)	<b>16.5</b> (14.4-19.2)	<b>20.8</b> (17.7-25.1)	<b>24.3</b> (20.2-29.9)	<b>28.0</b> (22.7-35.3)	<b>31.9</b> (25.1-41.3)	<b>37.4</b> (28.3-50.5)	<b>41.9</b> (30.6-58.4)
<b>60-day</b>	<b>8.17</b> (7.24-9.41)	<b>11.2</b> (9.95-13.0)	<b>15.4</b> (13.6-17.8)	<b>18.9</b> (16.5-22.0)	<b>23.8</b> (20.2-28.7)	<b>27.7</b> (23.0-34.1)	<b>31.8</b> (25.7-40.0)	<b>36.1</b> (28.4-46.7)	<b>42.1</b> (31.9-56.8)	<b>47.0</b> (34.4-65.6)

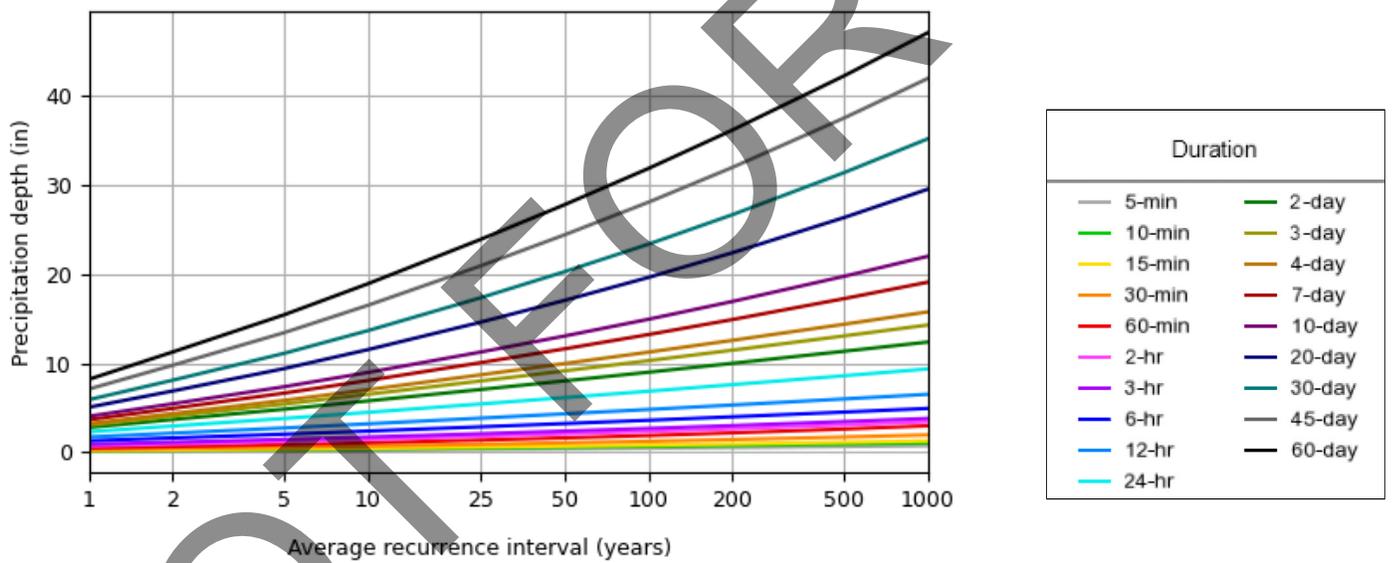
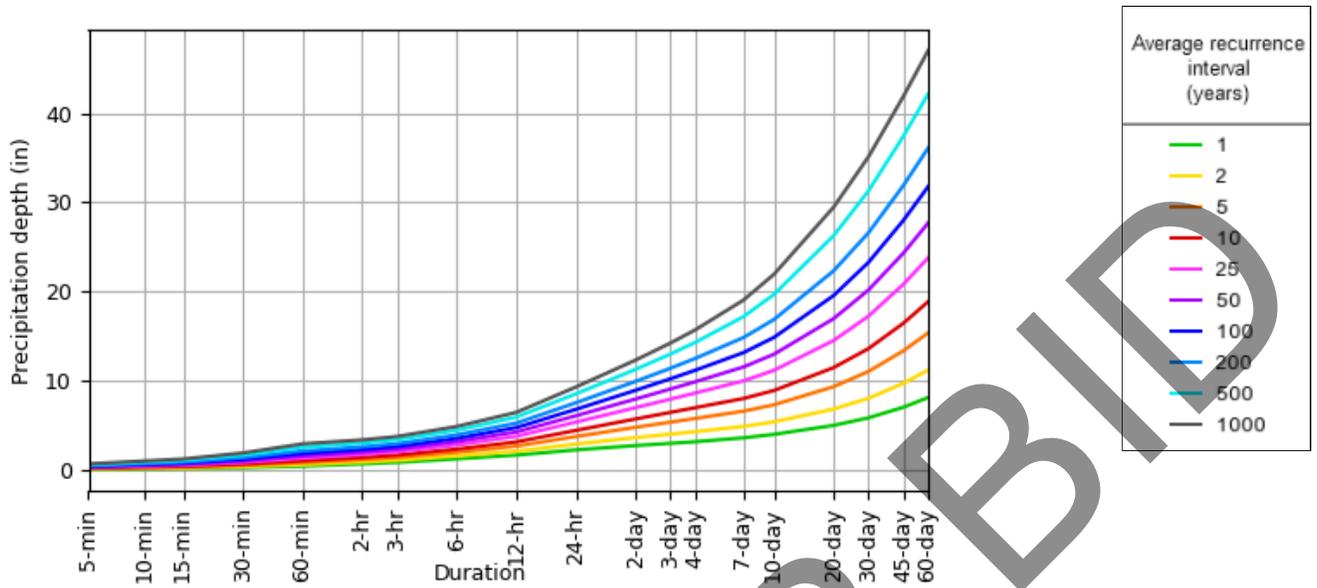
<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

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**PF graphical**

### PDS-based depth-duration-frequency (DDF) curves

Latitude: 34.1604°, Longitude: -117.2866°



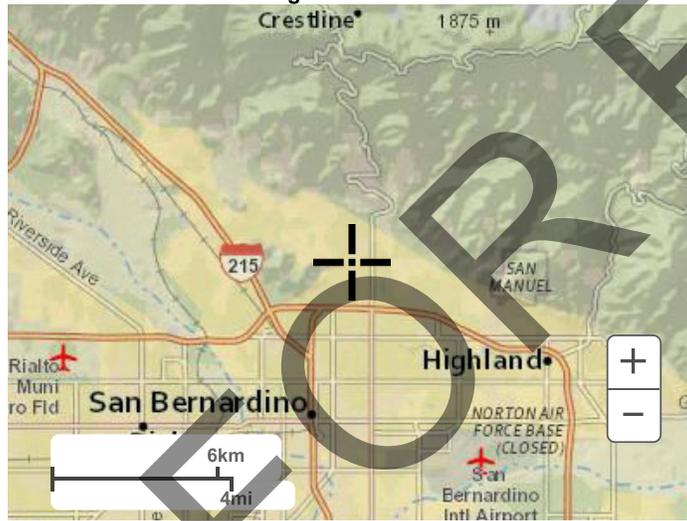
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**Maps & aerials**

**Small scale terrain**



Large scale terrain



Large scale map



Large scale aerial



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Silver Spring, MD 20910  
Questions?: [HDSC.Questions@noaa.gov](mailto:HDSC.Questions@noaa.gov)  
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APPENDIX 4. EXISTING RATIONAL  
METHOD AND HYDROGRAPH  
CALCULATIONS

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1  
Rational Hydrology Study Date: 06/18/25

-----  
SAN BERNARDINO COUNTY FIRE STATION No.227  
EXISTING HYDROLOY SCHOOL CONDITIONS  
AREA "A"  
-----

Program License Serial Number 6158

-----  
\*\*\*\*\* Hydrology Study Control Information \*\*\*\*\*  
-----

Rational hydrology study storm event year is 100.0  
Computed rainfall intensity:  
Storm year = 100.00 1 hour rainfall = 1.900 (In.)  
Slope used for rainfall intensity curve b = 0.6000  
Soil antecedent moisture condition (AMC) = 3

+++++  
Process from Point/Station 1.000 to Point/Station 2.000  
\*\*\*\* INITIAL AREA EVALUATION \*\*\*\*  
-----

SCHOOL subarea  
Decimal fraction soil group A = 1.000  
Decimal fraction soil group B = 0.000  
Decimal fraction soil group C = 0.000  
Decimal fraction soil group D = 0.000  
SCS curve number for soil(AMC 2) = 32.00  
Adjusted SCS curve number for AMC 3 = 52.00  
Pervious ratio(Ap) = 0.6000 Max loss rate(Fm)= 0.471(In/Hr)  
Initial subarea data:  
Initial area flow distance = 641.000(Ft.)  
Top (of initial area) elevation = 1294.000(Ft.)  
Bottom (of initial area) elevation = 1284.000(Ft.)  
Difference in elevation = 10.000(Ft.)  
Slope = 0.01560 s(%)= 1.56  
TC =  $k(0.412)*[(length^3)/(elevation\ change)]^{0.2}$   
Initial area time of concentration = 12.561 min.  
Rainfall intensity = 4.856(In/Hr) for a 100.0 year storm  
Effective runoff coefficient used for area (Q=KCIA) is C = 0.813  
Subarea runoff = 13.653(CFS)  
Total initial stream area = 3.460(Ac.)  
Pervious area fraction = 0.600  
Initial area Fm value = 0.471(In/Hr)  
End of computations, Total Study Area = 3.46 (Ac.)  
The following figures may  
be used for a unit hydrograph study of the same area.  
Note: These figures do not consider reduced effective area  
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 0.600  
Area averaged SCS curve number = 32.0

# TIME OF CONCENTRATION FOR HYDROGRAPH

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1  
Rational Hydrology Study Date: 06/17/25

-----  
Program License Serial Number 6158  
-----

\*\*\*\*\* Hydrology Study Control Information \*\*\*\*\*  
-----

Rational hydrology study storm event year is 100.0  
Computed rainfall intensity:  
Storm year = 100.00 1 hour rainfall = 1.900 (In.)  
Slope used for rainfall intensity curve b = 0.6000  
Soil antecedent moisture condition (AMC) = 3

\*\*\*\*\*  
Process from Point/Station 1.000 to Point/Station 2.000  
\*\*\*\* INITIAL AREA EVALUATION \*\*\*\*  
-----

UNDEVELOPED (dense cover) subarea  
Decimal fraction soil group A = 1.000  
Decimal fraction soil group B = 0.000  
Decimal fraction soil group C = 0.000  
Decimal fraction soil group D = 0.000  
SCS curve number for soil(AMC 2) = 38.00  
Adjusted SCS curve number for AMC 3 = 58.00  
Pervious ratio(Ap) = 1.0000 Max loss rate(Fm)= 0.707(In/Hr)  
Initial subarea data:  
Initial area flow distance = 292.000(Ft.)  
Top (of initial area) elevation = 1288.000(Ft.)  
Bottom (of initial area) elevation = 1284.000(Ft.)  
Difference in elevation = 4.000(Ft.)  
Slope = 0.01370 s(%)= 1.37  
TC =  $k(0.935)*[(\text{length}^3)/(\text{elevation change})]^{0.2}$   
Initial area time of concentration = 21.361 min.  
Rainfall intensity = 3.531(In/Hr) for a 100.0 year storm  
Effective runoff coefficient used for area (Q=KCIA) is C = 0.720  
Subarea runoff = 2.999(CFS)  
Total initial stream area = 1.180(Ac.)  
Pervious area fraction = 1.000  
Initial area Fm value = 0.707(In/Hr)  
End of computations, Total Study Area = 1.18 (Ac.)  
The following figures may  
be used for a unit hydrograph study of the same area.  
Note: These figures do not consider reduced effective area  
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 1.000  
Area averaged SCS curve number = 38.0

EXISTING CONDITION HYDROGRAPH

Unit Hydrograph Analysis

Copyright (c) CIVILCADD/CIVILDESIGN, 1989 - 2004, Version 7.0

Study date 06/17/25

San Bernardino County Synthetic Unit Hydrology Method
Manual date - August 1986

Program License Serial Number 6158

Storm Event Year = 100

Antecedent Moisture Condition = 3

English (in-lb) Input Units Used

English Rainfall Data (Inches) Input Values Used

English Units used in output format

Area averaged rainfall intensity isohyetal data:

Sub-Area Duration Isohyetal
(Ac.) (hours) (In)
Rainfall data for year 100
1.18 1 1.90

Rainfall data for year 100
1.18 6 3.60

Rainfall data for year 100
1.18 24 6.85

\*\*\*\*\* Area-averaged max loss rate, Fm \*\*\*\*\*

SCS curve SCS curve Area Area Fp(Fig C6) Ap Fm
No.(AMCII) NO.(AMC 3) (Ac.) Fraction (In/Hr) (dec.) (In/Hr)
44.0 64.0 1.18 1.000 0.623 1.000 0.623

Area-averaged adjusted loss rate Fm (In/Hr) = 0.623

\*\*\*\*\* Area-Averaged low loss rate fraction, Yb \*\*\*\*\*

Area Area SCS CN SCS CN S Pervious
(Ac.) Fract (AMC2) (AMC3) 5 Yield Fr
1.18 1.000 44.0 64.0 5.63 0.422

Area-averaged catchment yield fraction, Y = 0.422

Area-averaged low loss fraction, Yb = 0.578

User entry of time of concentration = 0.356 (hours)

Watershed area = 1.18(Ac.)

Catchment Lag time = 0.285 hours

Unit interval = 5.000 minutes

Unit interval percentage of lag time = 29.2603  
 Hydrograph baseflow = 0.00(CFS)  
 Average maximum watershed loss rate(Fm) = 0.623(In/Hr)  
 Average low loss rate fraction (Yb) = 0.578 (decimal)  
 VALLEY DEVELOPED S-Graph Selected  
 Computed peak 5-minute rainfall = 0.703(In)  
 Computed peak 30-minute rainfall = 1.440(In)  
 Specified peak 1-hour rainfall = 1.900(In)  
 Computed peak 3-hour rainfall = 2.811(In)  
 Specified peak 6-hour rainfall = 3.600(In)  
 Specified peak 24-hour rainfall = 6.850(In)

Rainfall depth area reduction factors:  
 Using a total area of 1.18(Ac.) (Ref: fig. E-4)

5-minute factor = 1.000 Adjusted rainfall = 0.703(In)  
 30-minute factor = 1.000 Adjusted rainfall = 1.440(In)  
 1-hour factor = 1.000 Adjusted rainfall = 1.900(In)  
 3-hour factor = 1.000 Adjusted rainfall = 2.811(In)  
 6-hour factor = 1.000 Adjusted rainfall = 3.600(In)  
 24-hour factor = 1.000 Adjusted rainfall = 6.850(In)

Unit Hydrograph

+++++

Interval Number	'S' Graph Mean values	Unit Hydrograph ((CFS))
(K = 14.27 (CFS))		
1	1.880	0.268
2	10.540	1.236
3	27.945	2.484
4	51.681	3.387
5	73.953	3.178
6	86.538	1.796
7	93.115	0.939
8	96.729	0.516
9	98.259	0.218
10	98.804	0.078
11	99.330	0.075
12	100.000	0.038

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Peak Unit Number	Adjusted mass rainfall (In)	Unit rainfall (In)
1	0.7032	0.7032
2	0.9278	0.2247
3	1.0912	0.1634
4	1.2243	0.1331
5	1.3386	0.1143
6	1.4399	0.1013
7	1.5314	0.0916
8	1.6154	0.0840
9	1.6934	0.0779
10	1.7663	0.0729
11	1.8349	0.0686
12	1.8999	0.0650
13	1.9549	0.0550
14	2.0073	0.0524
15	2.0573	0.0500
16	2.1052	0.0479
17	2.1512	0.0460
18	2.1956	0.0443
19	2.2383	0.0428
20	2.2796	0.0413
21	2.3197	0.0400
22	2.3585	0.0388
23	2.3962	0.0377

24	2.4328	0.0367
25	2.4685	0.0357
26	2.5033	0.0348
27	2.5372	0.0339
28	2.5704	0.0331
29	2.6027	0.0324
30	2.6344	0.0317
31	2.6654	0.0310
32	2.6958	0.0304
33	2.7255	0.0298
34	2.7547	0.0292
35	2.7833	0.0286
36	2.8114	0.0281
37	2.8391	0.0276
38	2.8662	0.0271
39	2.8929	0.0267
40	2.9191	0.0262
41	2.9449	0.0258
42	2.9703	0.0254
43	2.9954	0.0250
44	3.0200	0.0247
45	3.0444	0.0243
46	3.0683	0.0240
47	3.0919	0.0236
48	3.1152	0.0233
49	3.1382	0.0230
50	3.1609	0.0227
51	3.1833	0.0224
52	3.2055	0.0221
53	3.2273	0.0219
54	3.2489	0.0216
55	3.2702	0.0213
56	3.2913	0.0211
57	3.3122	0.0208
58	3.3328	0.0206
59	3.3532	0.0204
60	3.3733	0.0202
61	3.3933	0.0199
62	3.4130	0.0197
63	3.4325	0.0195
64	3.4519	0.0193
65	3.4710	0.0191
66	3.4900	0.0190
67	3.5087	0.0188
68	3.5273	0.0186
69	3.5458	0.0184
70	3.5640	0.0182
71	3.5821	0.0181
72	3.6000	0.0179
73	3.6231	0.0231
74	3.6461	0.0229
75	3.6688	0.0228
76	3.6915	0.0226
77	3.7139	0.0225
78	3.7362	0.0223
79	3.7584	0.0222
80	3.7804	0.0220
81	3.8022	0.0219
82	3.8239	0.0217
83	3.8455	0.0216
84	3.8669	0.0214
85	3.8882	0.0213
86	3.9094	0.0212
87	3.9304	0.0210
88	3.9513	0.0209
89	3.9721	0.0208
90	3.9928	0.0206
91	4.0133	0.0205
92	4.0337	0.0204

NOT FOR BID

93	4.0540	0.0203
94	4.0741	0.0202
95	4.0942	0.0201
96	4.1141	0.0199
97	4.1340	0.0198
98	4.1537	0.0197
99	4.1733	0.0196
100	4.1928	0.0195
101	4.2122	0.0194
102	4.2315	0.0193
103	4.2507	0.0192
104	4.2698	0.0191
105	4.2888	0.0190
106	4.3077	0.0189
107	4.3266	0.0188
108	4.3453	0.0187
109	4.3639	0.0186
110	4.3824	0.0185
111	4.4009	0.0184
112	4.4192	0.0184
113	4.4375	0.0183
114	4.4557	0.0182
115	4.4738	0.0181
116	4.4918	0.0180
117	4.5097	0.0179
118	4.5276	0.0178
119	4.5453	0.0178
120	4.5630	0.0177
121	4.5806	0.0176
122	4.5981	0.0175
123	4.6156	0.0175
124	4.6330	0.0174
125	4.6503	0.0173
126	4.6675	0.0172
127	4.6846	0.0172
128	4.7017	0.0171
129	4.7187	0.0170
130	4.7357	0.0169
131	4.7526	0.0169
132	4.7694	0.0168
133	4.7861	0.0167
134	4.8028	0.0167
135	4.8194	0.0166
136	4.8359	0.0165
137	4.8524	0.0165
138	4.8688	0.0164
139	4.8851	0.0163
140	4.9014	0.0163
141	4.9176	0.0162
142	4.9337	0.0162
143	4.9498	0.0161
144	4.9659	0.0160
145	4.9818	0.0160
146	4.9978	0.0159
147	5.0136	0.0159
148	5.0294	0.0158
149	5.0452	0.0157
150	5.0608	0.0157
151	5.0765	0.0156
152	5.0920	0.0156
153	5.1076	0.0155
154	5.1230	0.0155
155	5.1384	0.0154
156	5.1538	0.0154
157	5.1691	0.0153
158	5.1844	0.0153
159	5.1996	0.0152
160	5.2147	0.0151
161	5.2298	0.0151

NOT FOR BID

162	5.2448	0.0150
163	5.2598	0.0150
164	5.2748	0.0150
165	5.2897	0.0149
166	5.3046	0.0149
167	5.3194	0.0148
168	5.3341	0.0148
169	5.3488	0.0147
170	5.3635	0.0147
171	5.3781	0.0146
172	5.3927	0.0146
173	5.4072	0.0145
174	5.4217	0.0145
175	5.4361	0.0144
176	5.4505	0.0144
177	5.4649	0.0143
178	5.4792	0.0143
179	5.4934	0.0143
180	5.5077	0.0142
181	5.5218	0.0142
182	5.5360	0.0141
183	5.5501	0.0141
184	5.5641	0.0141
185	5.5781	0.0140
186	5.5921	0.0140
187	5.6060	0.0139
188	5.6199	0.0139
189	5.6338	0.0139
190	5.6476	0.0138
191	5.6614	0.0138
192	5.6751	0.0137
193	5.6888	0.0137
194	5.7025	0.0137
195	5.7161	0.0136
196	5.7297	0.0136
197	5.7432	0.0135
198	5.7567	0.0135
199	5.7702	0.0135
200	5.7836	0.0134
201	5.7970	0.0134
202	5.8104	0.0134
203	5.8237	0.0133
204	5.8370	0.0133
205	5.8503	0.0133
206	5.8635	0.0132
207	5.8767	0.0132
208	5.8899	0.0132
209	5.9030	0.0131
210	5.9161	0.0131
211	5.9291	0.0131
212	5.9422	0.0130
213	5.9552	0.0130
214	5.9681	0.0130
215	5.9810	0.0129
216	5.9939	0.0129
217	6.0068	0.0129
218	6.0196	0.0128
219	6.0324	0.0128
220	6.0452	0.0128
221	6.0579	0.0127
222	6.0706	0.0127
223	6.0833	0.0127
224	6.0959	0.0126
225	6.1086	0.0126
226	6.1211	0.0126
227	6.1337	0.0126
228	6.1462	0.0125
229	6.1587	0.0125
230	6.1712	0.0125

NOT FOR BID

231	6.1836	0.0124
232	6.1960	0.0124
233	6.2084	0.0124
234	6.2208	0.0124
235	6.2331	0.0123
236	6.2454	0.0123
237	6.2576	0.0123
238	6.2699	0.0122
239	6.2821	0.0122
240	6.2943	0.0122
241	6.3064	0.0122
242	6.3186	0.0121
243	6.3307	0.0121
244	6.3427	0.0121
245	6.3548	0.0120
246	6.3668	0.0120
247	6.3788	0.0120
248	6.3908	0.0120
249	6.4027	0.0119
250	6.4146	0.0119
251	6.4265	0.0119
252	6.4384	0.0119
253	6.4503	0.0118
254	6.4621	0.0118
255	6.4739	0.0118
256	6.4856	0.0118
257	6.4974	0.0117
258	6.5091	0.0117
259	6.5208	0.0117
260	6.5325	0.0117
261	6.5441	0.0116
262	6.5557	0.0116
263	6.5673	0.0116
264	6.5789	0.0116
265	6.5905	0.0116
266	6.6020	0.0115
267	6.6135	0.0115
268	6.6250	0.0115
269	6.6364	0.0115
270	6.6479	0.0114
271	6.6593	0.0114
272	6.6707	0.0114
273	6.6821	0.0114
274	6.6934	0.0113
275	6.7047	0.0113
276	6.7160	0.0113
277	6.7273	0.0113
278	6.7386	0.0113
279	6.7498	0.0112
280	6.7610	0.0112
281	6.7722	0.0112
282	6.7834	0.0112
283	6.7945	0.0112
284	6.8057	0.0111
285	6.8168	0.0111
286	6.8279	0.0111
287	6.8389	0.0111
288	6.8500	0.0110

Unit Period (number)	Unit Rainfall (In)	Unit Soil-Loss (In)	Effective Rainfall (In)
1	0.0110	0.0064	0.0047
2	0.0111	0.0064	0.0047
3	0.0111	0.0064	0.0047
4	0.0111	0.0064	0.0047
5	0.0112	0.0065	0.0047
6	0.0112	0.0065	0.0047

7	0.0112	0.0065	0.0047
8	0.0113	0.0065	0.0047
9	0.0113	0.0065	0.0048
10	0.0113	0.0066	0.0048
11	0.0114	0.0066	0.0048
12	0.0114	0.0066	0.0048
13	0.0114	0.0066	0.0048
14	0.0115	0.0066	0.0048
15	0.0115	0.0067	0.0049
16	0.0115	0.0067	0.0049
17	0.0116	0.0067	0.0049
18	0.0116	0.0067	0.0049
19	0.0116	0.0067	0.0049
20	0.0117	0.0068	0.0049
21	0.0117	0.0068	0.0049
22	0.0117	0.0068	0.0050
23	0.0118	0.0068	0.0050
24	0.0118	0.0068	0.0050
25	0.0119	0.0069	0.0050
26	0.0119	0.0069	0.0050
27	0.0119	0.0069	0.0050
28	0.0120	0.0069	0.0050
29	0.0120	0.0070	0.0051
30	0.0120	0.0070	0.0051
31	0.0121	0.0070	0.0051
32	0.0121	0.0070	0.0051
33	0.0122	0.0070	0.0051
34	0.0122	0.0071	0.0051
35	0.0123	0.0071	0.0052
36	0.0123	0.0071	0.0052
37	0.0124	0.0071	0.0052
38	0.0124	0.0072	0.0052
39	0.0124	0.0072	0.0052
40	0.0125	0.0072	0.0053
41	0.0125	0.0072	0.0053
42	0.0126	0.0073	0.0053
43	0.0126	0.0073	0.0053
44	0.0126	0.0073	0.0053
45	0.0127	0.0073	0.0054
46	0.0127	0.0074	0.0054
47	0.0128	0.0074	0.0054
48	0.0128	0.0074	0.0054
49	0.0129	0.0075	0.0054
50	0.0129	0.0075	0.0054
51	0.0130	0.0075	0.0055
52	0.0130	0.0075	0.0055
53	0.0131	0.0076	0.0055
54	0.0131	0.0076	0.0055
55	0.0132	0.0076	0.0056
56	0.0132	0.0077	0.0056
57	0.0133	0.0077	0.0056
58	0.0133	0.0077	0.0056
59	0.0134	0.0078	0.0056
60	0.0134	0.0078	0.0057
61	0.0135	0.0078	0.0057
62	0.0135	0.0078	0.0057
63	0.0136	0.0079	0.0057
64	0.0137	0.0079	0.0058
65	0.0137	0.0079	0.0058
66	0.0138	0.0080	0.0058
67	0.0139	0.0080	0.0058
68	0.0139	0.0080	0.0059
69	0.0140	0.0081	0.0059
70	0.0140	0.0081	0.0059
71	0.0141	0.0082	0.0059
72	0.0141	0.0082	0.0060
73	0.0142	0.0082	0.0060
74	0.0143	0.0083	0.0060
75	0.0143	0.0083	0.0060

NOT FOR BID

76	0.0144	0.0083	0.0061
77	0.0145	0.0084	0.0061
78	0.0145	0.0084	0.0061
79	0.0146	0.0085	0.0062
80	0.0147	0.0085	0.0062
81	0.0148	0.0085	0.0062
82	0.0148	0.0086	0.0062
83	0.0149	0.0086	0.0063
84	0.0150	0.0086	0.0063
85	0.0150	0.0087	0.0063
86	0.0151	0.0087	0.0064
87	0.0152	0.0088	0.0064
88	0.0153	0.0088	0.0064
89	0.0154	0.0089	0.0065
90	0.0154	0.0089	0.0065
91	0.0155	0.0090	0.0065
92	0.0156	0.0090	0.0066
93	0.0157	0.0091	0.0066
94	0.0157	0.0091	0.0066
95	0.0159	0.0092	0.0067
96	0.0159	0.0092	0.0067
97	0.0160	0.0093	0.0068
98	0.0161	0.0093	0.0068
99	0.0162	0.0094	0.0068
100	0.0163	0.0094	0.0069
101	0.0164	0.0095	0.0069
102	0.0165	0.0095	0.0069
103	0.0166	0.0096	0.0070
104	0.0167	0.0096	0.0070
105	0.0168	0.0097	0.0071
106	0.0169	0.0098	0.0071
107	0.0170	0.0098	0.0072
108	0.0171	0.0099	0.0072
109	0.0172	0.0100	0.0073
110	0.0173	0.0100	0.0073
111	0.0175	0.0101	0.0074
112	0.0175	0.0101	0.0074
113	0.0177	0.0102	0.0075
114	0.0178	0.0103	0.0075
115	0.0179	0.0104	0.0076
116	0.0180	0.0104	0.0076
117	0.0182	0.0105	0.0077
118	0.0183	0.0106	0.0077
119	0.0184	0.0107	0.0078
120	0.0185	0.0107	0.0078
121	0.0187	0.0108	0.0079
122	0.0188	0.0109	0.0079
123	0.0190	0.0110	0.0080
124	0.0191	0.0110	0.0081
125	0.0193	0.0112	0.0081
126	0.0194	0.0112	0.0082
127	0.0196	0.0113	0.0083
128	0.0197	0.0114	0.0083
129	0.0199	0.0115	0.0084
130	0.0201	0.0116	0.0085
131	0.0203	0.0117	0.0086
132	0.0204	0.0118	0.0086
133	0.0206	0.0119	0.0087
134	0.0208	0.0120	0.0088
135	0.0210	0.0122	0.0089
136	0.0212	0.0122	0.0089
137	0.0214	0.0124	0.0090
138	0.0216	0.0125	0.0091
139	0.0219	0.0126	0.0092
140	0.0220	0.0127	0.0093
141	0.0223	0.0129	0.0094
142	0.0225	0.0130	0.0095
143	0.0228	0.0132	0.0096
144	0.0229	0.0133	0.0097

NOT FOR BID

145	0.0179	0.0104	0.0076
146	0.0181	0.0105	0.0076
147	0.0184	0.0107	0.0078
148	0.0186	0.0108	0.0078
149	0.0190	0.0110	0.0080
150	0.0191	0.0111	0.0081
151	0.0195	0.0113	0.0082
152	0.0197	0.0114	0.0083
153	0.0202	0.0117	0.0085
154	0.0204	0.0118	0.0086
155	0.0208	0.0121	0.0088
156	0.0211	0.0122	0.0089
157	0.0216	0.0125	0.0091
158	0.0219	0.0126	0.0092
159	0.0224	0.0130	0.0094
160	0.0227	0.0131	0.0096
161	0.0233	0.0135	0.0098
162	0.0236	0.0137	0.0100
163	0.0243	0.0141	0.0102
164	0.0247	0.0143	0.0104
165	0.0254	0.0147	0.0107
166	0.0258	0.0149	0.0109
167	0.0267	0.0154	0.0112
168	0.0271	0.0157	0.0114
169	0.0281	0.0163	0.0119
170	0.0286	0.0166	0.0121
171	0.0298	0.0172	0.0125
172	0.0304	0.0176	0.0128
173	0.0317	0.0183	0.0133
174	0.0324	0.0187	0.0136
175	0.0339	0.0196	0.0143
176	0.0348	0.0201	0.0147
177	0.0367	0.0212	0.0155
178	0.0377	0.0218	0.0159
179	0.0400	0.0232	0.0169
180	0.0413	0.0239	0.0174
181	0.0443	0.0256	0.0187
182	0.0460	0.0266	0.0194
183	0.0500	0.0289	0.0211
184	0.0524	0.0303	0.0221
185	0.0650	0.0376	0.0274
186	0.0686	0.0397	0.0289
187	0.0779	0.0451	0.0329
188	0.0840	0.0486	0.0354
189	0.1013	0.0519	0.0494
190	0.1143	0.0519	0.0624
191	0.1634	0.0519	0.1115
192	0.2247	0.0519	0.1728
193	0.7032	0.0519	0.6513
194	0.1331	0.0519	0.0812
195	0.0916	0.0519	0.0397
196	0.0729	0.0422	0.0307
197	0.0550	0.0318	0.0232
198	0.0479	0.0277	0.0202
199	0.0428	0.0247	0.0180
200	0.0388	0.0225	0.0164
201	0.0357	0.0206	0.0150
202	0.0331	0.0192	0.0140
203	0.0310	0.0179	0.0131
204	0.0292	0.0169	0.0123
205	0.0276	0.0160	0.0116
206	0.0262	0.0152	0.0111
207	0.0250	0.0145	0.0106
208	0.0240	0.0139	0.0101
209	0.0230	0.0133	0.0097
210	0.0221	0.0128	0.0093
211	0.0213	0.0123	0.0090
212	0.0206	0.0119	0.0087
213	0.0199	0.0115	0.0084



214	0.0193	0.0112	0.0082
215	0.0188	0.0109	0.0079
216	0.0182	0.0106	0.0077
217	0.0231	0.0134	0.0097
218	0.0226	0.0131	0.0095
219	0.0222	0.0128	0.0093
220	0.0217	0.0126	0.0092
221	0.0213	0.0123	0.0090
222	0.0209	0.0121	0.0088
223	0.0205	0.0119	0.0087
224	0.0202	0.0117	0.0085
225	0.0198	0.0115	0.0084
226	0.0195	0.0113	0.0082
227	0.0192	0.0111	0.0081
228	0.0189	0.0109	0.0080
229	0.0186	0.0108	0.0079
230	0.0184	0.0106	0.0077
231	0.0181	0.0105	0.0076
232	0.0178	0.0103	0.0075
233	0.0176	0.0102	0.0074
234	0.0174	0.0101	0.0073
235	0.0172	0.0099	0.0072
236	0.0169	0.0098	0.0071
237	0.0167	0.0097	0.0071
238	0.0165	0.0096	0.0070
239	0.0163	0.0095	0.0069
240	0.0162	0.0093	0.0068
241	0.0160	0.0092	0.0067
242	0.0158	0.0091	0.0067
243	0.0156	0.0090	0.0066
244	0.0155	0.0089	0.0065
245	0.0153	0.0089	0.0065
246	0.0151	0.0088	0.0064
247	0.0150	0.0087	0.0063
248	0.0149	0.0086	0.0063
249	0.0147	0.0085	0.0062
250	0.0146	0.0084	0.0061
251	0.0144	0.0084	0.0061
252	0.0143	0.0083	0.0060
253	0.0142	0.0082	0.0060
254	0.0141	0.0081	0.0059
255	0.0139	0.0081	0.0059
256	0.0138	0.0080	0.0058
257	0.0137	0.0079	0.0058
258	0.0136	0.0079	0.0057
259	0.0135	0.0078	0.0057
260	0.0134	0.0077	0.0056
261	0.0133	0.0077	0.0056
262	0.0132	0.0076	0.0055
263	0.0131	0.0076	0.0055
264	0.0130	0.0075	0.0055
265	0.0129	0.0074	0.0054
266	0.0128	0.0074	0.0054
267	0.0127	0.0073	0.0053
268	0.0126	0.0073	0.0053
269	0.0125	0.0072	0.0053
270	0.0124	0.0072	0.0052
271	0.0123	0.0071	0.0052
272	0.0122	0.0071	0.0052
273	0.0122	0.0070	0.0051
274	0.0121	0.0070	0.0051
275	0.0120	0.0069	0.0051
276	0.0119	0.0069	0.0050
277	0.0118	0.0069	0.0050
278	0.0118	0.0068	0.0050
279	0.0117	0.0068	0.0049
280	0.0116	0.0067	0.0049
281	0.0116	0.0067	0.0049
282	0.0115	0.0066	0.0048

NOT FOR BID

283	0.0114	0.0066	0.0048
284	0.0113	0.0066	0.0048
285	0.0113	0.0065	0.0048
286	0.0112	0.0065	0.0047
287	0.0112	0.0065	0.0047
288	0.0111	0.0064	0.0047

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Total soil rain loss = 3.44(In)  
Total effective rainfall = 3.41(In)  
Peak flow rate in flood hydrograph = 3.31(CFS)  
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+++++  
24 - H O U R S T O R M  
R u n o f f H y d r o g r a p h  
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Hydrograph in 5 Minute intervals ((CFS))  
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Time(h+m)	Volume Ac.Ft	Q(CFS)	0	2.5	5.0	7.5	10.0
0+ 5	0.0000	0.00	Q				
0+10	0.0001	0.01	Q				
0+15	0.0002	0.02	Q				
0+20	0.0004	0.03	Q				
0+25	0.0008	0.05	Q				
0+30	0.0012	0.06	Q				
0+35	0.0016	0.06	Q				
0+40	0.0020	0.06	Q				
0+45	0.0025	0.07	Q				
0+50	0.0030	0.07	Q				
0+55	0.0034	0.07	Q				
1+ 0	0.0039	0.07	Q				
1+ 5	0.0043	0.07	Q				
1+10	0.0048	0.07	Q				
1+15	0.0053	0.07	Q				
1+20	0.0058	0.07	Q				
1+25	0.0062	0.07	Q				
1+30	0.0067	0.07	Q				
1+35	0.0072	0.07	Q				
1+40	0.0077	0.07	Q				
1+45	0.0081	0.07	Q				
1+50	0.0086	0.07	QV				
1+55	0.0091	0.07	QV				
2+ 0	0.0096	0.07	QV				
2+ 5	0.0101	0.07	QV				
2+10	0.0105	0.07	QV				
2+15	0.0110	0.07	QV				
2+20	0.0115	0.07	QV				
2+25	0.0120	0.07	QV				
2+30	0.0125	0.07	QV				
2+35	0.0130	0.07	QV				
2+40	0.0135	0.07	QV				
2+45	0.0140	0.07	QV				
2+50	0.0145	0.07	QV				
2+55	0.0150	0.07	QV				
3+ 0	0.0155	0.07	QV				
3+ 5	0.0160	0.07	QV				
3+10	0.0165	0.07	QV				
3+15	0.0170	0.07	Q V				
3+20	0.0175	0.07	Q V				
3+25	0.0180	0.07	Q V				
3+30	0.0185	0.07	Q V				
3+35	0.0190	0.07	Q V				
3+40	0.0196	0.07	Q V				
3+45	0.0201	0.08	Q V				
3+50	0.0206	0.08	Q V				
3+55	0.0211	0.08	Q V				
4+ 0	0.0216	0.08	Q V				

4+ 5	0.0222	0.08	Q	V
4+10	0.0227	0.08	Q	V
4+15	0.0232	0.08	Q	V
4+20	0.0237	0.08	Q	V
4+25	0.0243	0.08	Q	V
4+30	0.0248	0.08	Q	V
4+35	0.0254	0.08	Q	V
4+40	0.0259	0.08	Q	V
4+45	0.0264	0.08	Q	V
4+50	0.0270	0.08	Q	V
4+55	0.0275	0.08	Q	V
5+ 0	0.0281	0.08	Q	V
5+ 5	0.0286	0.08	Q	V
5+10	0.0292	0.08	Q	V
5+15	0.0297	0.08	Q	V
5+20	0.0303	0.08	Q	V
5+25	0.0308	0.08	Q	V
5+30	0.0314	0.08	Q	V
5+35	0.0320	0.08	Q	V
5+40	0.0325	0.08	Q	V
5+45	0.0331	0.08	Q	V
5+50	0.0337	0.08	Q	V
5+55	0.0342	0.08	Q	V
6+ 0	0.0348	0.08	Q	V
6+ 5	0.0354	0.08	Q	V
6+10	0.0360	0.08	Q	V
6+15	0.0365	0.08	Q	V
6+20	0.0371	0.08	Q	V
6+25	0.0377	0.09	Q	V
6+30	0.0383	0.09	Q	V
6+35	0.0389	0.09	Q	V
6+40	0.0395	0.09	Q	V
6+45	0.0401	0.09	Q	V
6+50	0.0407	0.09	Q	V
6+55	0.0413	0.09	Q	V
7+ 0	0.0419	0.09	Q	V
7+ 5	0.0425	0.09	Q	V
7+10	0.0431	0.09	Q	V
7+15	0.0437	0.09	Q	V
7+20	0.0444	0.09	Q	V
7+25	0.0450	0.09	Q	V
7+30	0.0456	0.09	Q	V
7+35	0.0462	0.09	Q	V
7+40	0.0469	0.09	Q	V
7+45	0.0475	0.09	Q	V
7+50	0.0481	0.09	Q	V
7+55	0.0488	0.09	Q	V
8+ 0	0.0494	0.09	Q	V
8+ 5	0.0501	0.09	Q	V
8+10	0.0507	0.09	Q	V
8+15	0.0514	0.10	Q	V
8+20	0.0520	0.10	Q	V
8+25	0.0527	0.10	Q	V
8+30	0.0534	0.10	Q	V
8+35	0.0540	0.10	Q	V
8+40	0.0547	0.10	Q	V
8+45	0.0554	0.10	Q	V
8+50	0.0561	0.10	Q	V
8+55	0.0568	0.10	Q	V
9+ 0	0.0575	0.10	Q	V
9+ 5	0.0581	0.10	Q	V
9+10	0.0588	0.10	Q	V
9+15	0.0596	0.10	Q	V
9+20	0.0603	0.10	Q	V
9+25	0.0610	0.10	Q	V
9+30	0.0617	0.10	Q	V
9+35	0.0624	0.10	Q	V
9+40	0.0631	0.11	Q	V
9+45	0.0639	0.11	Q	V

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9+50	0.0646	0.11	Q	V				
9+55	0.0653	0.11	Q	V				
10+ 0	0.0661	0.11	Q	V				
10+ 5	0.0668	0.11	Q	V				
10+10	0.0676	0.11	Q	V				
10+15	0.0684	0.11	Q	V				
10+20	0.0691	0.11	Q	V				
10+25	0.0699	0.11	Q	V				
10+30	0.0707	0.11	Q	V				
10+35	0.0715	0.11	Q	V				
10+40	0.0723	0.12	Q	V				
10+45	0.0731	0.12	Q	V				
10+50	0.0739	0.12	Q	V				
10+55	0.0747	0.12	Q	V				
11+ 0	0.0755	0.12	Q	V				
11+ 5	0.0763	0.12	Q	V				
11+10	0.0772	0.12	Q	V				
11+15	0.0780	0.12	Q	V				
11+20	0.0788	0.12	Q	V				
11+25	0.0797	0.12	Q	V				
11+30	0.0806	0.13	Q	V				
11+35	0.0814	0.13	Q	V				
11+40	0.0823	0.13	Q	V				
11+45	0.0832	0.13	Q	V				
11+50	0.0841	0.13	Q	V				
11+55	0.0850	0.13	Q	V				
12+ 0	0.0859	0.13	Q	V				
12+ 5	0.0868	0.13	Q	V				
12+10	0.0877	0.13	Q	V				
12+15	0.0886	0.13	Q	V				
12+20	0.0895	0.12	Q	V				
12+25	0.0902	0.12	Q	V				
12+30	0.0910	0.11	Q	V				
12+35	0.0918	0.11	Q	V				
12+40	0.0926	0.11	Q	V				
12+45	0.0934	0.11	Q	V				
12+50	0.0942	0.12	Q	V				
12+55	0.0950	0.12	Q	V				
13+ 0	0.0958	0.12	Q	V				
13+ 5	0.0966	0.12	Q	V				
13+10	0.0975	0.12	Q	V				
13+15	0.0984	0.13	Q	V				
13+20	0.0992	0.13	Q	V				
13+25	0.1001	0.13	Q	V				
13+30	0.1011	0.13	Q	V				
13+35	0.1020	0.14	Q	V				
13+40	0.1029	0.14	Q	V				
13+45	0.1039	0.14	Q	V				
13+50	0.1049	0.14	Q	V				
13+55	0.1059	0.15	Q	V				
14+ 0	0.1069	0.15	Q	V				
14+ 5	0.1080	0.15	Q	V				
14+10	0.1091	0.16	Q	V				
14+15	0.1102	0.16	Q	V				
14+20	0.1113	0.17	Q	V				
14+25	0.1125	0.17	Q	V				
14+30	0.1137	0.17	Q	V				
14+35	0.1149	0.18	Q	V				
14+40	0.1162	0.19	Q	V				
14+45	0.1175	0.19	Q	V				
14+50	0.1189	0.20	Q	V				
14+55	0.1203	0.21	Q	V				
15+ 0	0.1218	0.21	Q	V				
15+ 5	0.1234	0.22	Q	V				
15+10	0.1250	0.23	Q	V				
15+15	0.1266	0.24	Q	V				
15+20	0.1284	0.26	Q	V				
15+25	0.1303	0.27	Q	V				
15+30	0.1323	0.29	Q	V				

NOT FOR BID

15+35	0.1346	0.32	Q		V		
15+40	0.1370	0.36	Q		V		
15+45	0.1398	0.40	Q		V		
15+50	0.1429	0.46	Q		V		
15+55	0.1467	0.55	Q		V		
16+ 0	0.1517	0.73	Q		V		
16+ 5	0.1597	1.15	Q	Q	V		
16+10	0.1733	1.98	Q	Q	V		
16+15	0.1930	2.86		Q	V		
16+20	0.2158	3.31		Q	V		
16+25	0.2361	2.95		Q	V		
16+30	0.2493	1.91	Q		V		
16+35	0.2576	1.20	Q		V		
16+40	0.2630	0.79	Q		V		
16+45	0.2665	0.51	Q		V		
16+50	0.2690	0.36	Q		V		
16+55	0.2712	0.32	Q		V		
17+ 0	0.2730	0.26	Q		V		
17+ 5	0.2745	0.22	Q		V		
17+10	0.2759	0.20	Q		V		
17+15	0.2771	0.18	Q		V		
17+20	0.2783	0.17	Q		V		
17+25	0.2795	0.16	Q		V		
17+30	0.2805	0.16	Q		V		
17+35	0.2816	0.15	Q		V		
17+40	0.2825	0.14	Q		V		
17+45	0.2835	0.14	Q		V		
17+50	0.2844	0.13	Q		V		
17+55	0.2852	0.13	Q		V		
18+ 0	0.2861	0.12	Q		V		
18+ 5	0.2869	0.12	Q		V		
18+10	0.2877	0.12	Q		V		
18+15	0.2886	0.12	Q		V		
18+20	0.2894	0.12	Q		V		
18+25	0.2903	0.13	Q		V		
18+30	0.2912	0.13	Q		V		
18+35	0.2921	0.13	Q		V		
18+40	0.2930	0.13	Q		V		
18+45	0.2939	0.13	Q		V		
18+50	0.2947	0.12	Q		V		
18+55	0.2955	0.12	Q		V		
19+ 0	0.2964	0.12	Q		V		
19+ 5	0.2972	0.12	Q		V		
19+10	0.2980	0.12	Q		V		
19+15	0.2988	0.11	Q		V		
19+20	0.2996	0.11	Q		V		
19+25	0.3003	0.11	Q		V		
19+30	0.3011	0.11	Q		V		
19+35	0.3018	0.11	Q		V		
19+40	0.3025	0.11	Q		V		
19+45	0.3033	0.10	Q		V		
19+50	0.3040	0.10	Q		V		
19+55	0.3047	0.10	Q		V		
20+ 0	0.3054	0.10	Q		V		
20+ 5	0.3061	0.10	Q		V		
20+10	0.3068	0.10	Q		V		
20+15	0.3074	0.10	Q		V		
20+20	0.3081	0.10	Q		V		
20+25	0.3087	0.10	Q		V		
20+30	0.3094	0.09	Q		V		
20+35	0.3100	0.09	Q		V		
20+40	0.3107	0.09	Q		V		
20+45	0.3113	0.09	Q		V		
20+50	0.3119	0.09	Q		V		
20+55	0.3125	0.09	Q		V		
21+ 0	0.3132	0.09	Q		V		
21+ 5	0.3138	0.09	Q		V		
21+10	0.3144	0.09	Q		V		
21+15	0.3149	0.09	Q		V		

NOT FOR BID

21+20	0.3155	0.09	Q	V
21+25	0.3161	0.08	Q	V
21+30	0.3167	0.08	Q	V
21+35	0.3173	0.08	Q	V
21+40	0.3178	0.08	Q	V
21+45	0.3184	0.08	Q	V
21+50	0.3190	0.08	Q	V
21+55	0.3195	0.08	Q	V
22+ 0	0.3201	0.08	Q	V
22+ 5	0.3206	0.08	Q	V
22+10	0.3212	0.08	Q	V
22+15	0.3217	0.08	Q	V
22+20	0.3222	0.08	Q	V
22+25	0.3228	0.08	Q	V
22+30	0.3233	0.08	Q	V
22+35	0.3238	0.08	Q	V
22+40	0.3243	0.08	Q	V
22+45	0.3248	0.07	Q	V
22+50	0.3253	0.07	Q	V
22+55	0.3258	0.07	Q	V
23+ 0	0.3264	0.07	Q	V
23+ 5	0.3269	0.07	Q	V
23+10	0.3273	0.07	Q	V
23+15	0.3278	0.07	Q	V
23+20	0.3283	0.07	Q	V
23+25	0.3288	0.07	Q	V
23+30	0.3293	0.07	Q	V
23+35	0.3298	0.07	Q	V
23+40	0.3303	0.07	Q	V
23+45	0.3307	0.07	Q	V
23+50	0.3312	0.07	Q	V
23+55	0.3317	0.07	Q	V
24+ 0	0.3322	0.07	Q	V
24+ 5	0.3326	0.07	Q	V
24+10	0.3330	0.06	Q	V
24+15	0.3334	0.05	Q	V
24+20	0.3336	0.03	Q	V
24+25	0.3337	0.02	Q	V
24+30	0.3338	0.01	Q	V
24+35	0.3338	0.00	Q	V
24+40	0.3338	0.00	Q	V
24+45	0.3338	0.00	Q	V
24+50	0.3338	0.00	Q	V
24+55	0.3338	0.00	Q	V

NOT FOR BID